SOIL SURVEY OF

Walsh County, North Dakota

United States Department of Agriculture
Soil Conservation Service
In cooperation with
North Dakota Agricultural Experiment Station

Issued September 1972

Major fieldwork for this soil survey was done in the period 1953–64. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1966. This survey was made cooperatively by the Soil Conservation Service and the North Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Walsh County and Three Rivers Conservation Districts.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Walsh County are shown on the detailed soil map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the windbreak site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units.

Foresters and others can refer to the section "Use of Soils for Windbreaks," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of Soils for Wildlife."

Engineers and builders can find, under "Use of Soils for Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of Soils."

Newcomers in Walsh County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given at the beginning of the publication.

Cover picture:
Aerial view of Lankin-Gilby association south of Park River.

U.S. GOVERNMENT PRINTING OFFICE: 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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Issued September 1972

419-202—72——1

SOIL SURVEY OF WALSH COUNTY, NORTH DAKOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

WALSH COUNTY is in the northeastern part of North Dakota, 40 miles south of the Canadian border (fig. 1). The county occupies approximately 1,287 square miles, or 823,680 acres. Its eastern boundary is the Red River of the North, in this survey referred to as the Red River. Grafton, the county seat, is in the east-central part of the county.

The county consists of a nearly level glacial lake plain in the east; of a narrow area of lake beach lines, glacial moraines, and delta deposits in the center; and of a rolling and undulating ground moraine in the west. Natural drainage is in an easterly direction, and the smaller streams empty into the Park River and the Forest River. These rivers are tributaries of the north-flowing Red River.

Natural lakes are few, but they are important rest areas for migratory waterfowl. Many artificial reservoirs have been constructed since 1950 for recreation and flood control. One of the largest is formed by the Homme Dam.

Most of the soils in the county are deep or moderately deep and are well suited to cultivated crops. Somewhat poor or poor surface drainage of the nearly level soils and of the soils in depressions makes management difficult in wet periods. Most of the soils are moderately to highly susceptible to soil blowing if they are not protected, and some of the soils are saline. These characteristics lower the value of the soils for growing crops. Hard red spring wheat and durum wheat are the main crops, but barley, potatoes, and flax are also grown extensively.

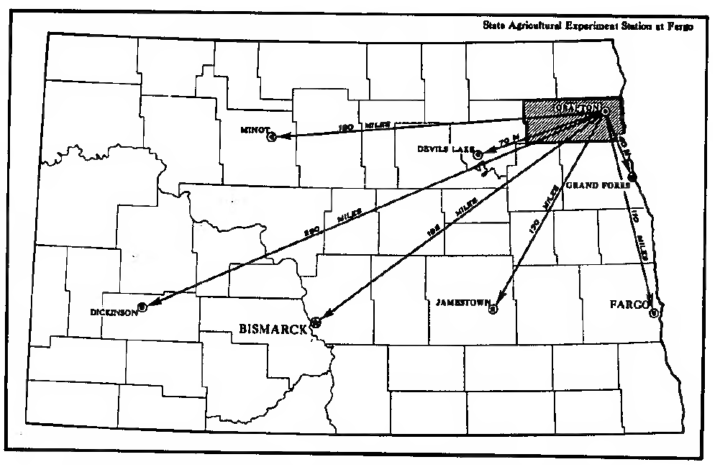

Figure 1.—Location of Walsh County in North Dakota.

About 6 percent of the county is in native timber. The wooded areas are mainly along the Red River and its major tributaries, but small areas are also west of Edinburg. Since 1935, farmstead windbreaks and field windbreaks have been planted in increasing numbers.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Walsh County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Barnes and Fargo, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Cashel silty clay, nearly level, is one of several phases within the Cashel series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photo-

graphs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Walsh County: soil complexes and undifferentiated groups.

A soil complex consists of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Barnes-Sioux complex, hilly.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Hamar and Ulen loamy sands is an example.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Walsh County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Walsh County are discussed in the following pages.

Soils of the Glacial Till Plains

Soils of the glacial till plains are in the western half of the county. Some are on ground moraines, others are on a terminal moraine that bisects the central part of the county from north to south, and still others are on the sides of valleys, where streams have cut into the till plain. The soils on ground moraines are nearly level to rolling and undulating; those on the terminal moraine are rolling and hilly; and those on the sides of valleys are strongly sloping to hilly. Soils along the sides of the valley of the Park River and in adjacent areas are shallow over shale bedrock of late Cretaceous age. Shale bedrock crops out in a few places.

Soils of the glacial till plains have formed in calcareous loam or clay loam glacial till and in alluvium derived from the till. Seven soil associations are in this group.

1. Cresbard-Hamerly-Svea association

Deep, nearly level, moderately well drained and somewhat poorly drained loamy soils

This association consists of nearly level areas of low local relief, mainly in the northwestern corner of Walsh County. It occupies about 2 percent of the county.

Cresbard soils make up about 60 percent of this association. These soils have a surface layer of very dark gray loam, about 7 inches thick, and a dark grayish-brown subsoil that is a claypan. Just below the subsoil, they have a layer of white clay loam that contains a large amount of lime and some salts. The Cresbard soils are moderately well drained, and they have high available water capacity. Permeability is moderate in the surface layer, and it is moderately slow in the subsoil and the substratum.

Hamerly soils make up about 20 percent of this association. They have a loam surface layer that is about 14 inches thick and is very dark gray in the upper part and is grayish brown in the lower part. The surface layer is more calcareous in the lower part than in the upper part. It is underlain by pale-yellow clay loam that contains a large amount of lime. The Hamerly soils are moderately well drained or somewhat poorly drained, and they have high available water capacity. Permeability is moderate in the surface layer and in the limy material, and it is slow in the clay loam glacial till.

Svea soils make up about 15 percent of this association. These soils have a surface layer of very dark gray loam about 8 inches thick. Their subsoil is clay loam that is about 11 inches thick and is dark gray in the upper part and grayish brown in the lower part. Just beneath the subsoil is a layer of clay loam, about 20 inches thick, that contains a large amount of lime. This layer is white in the upper part and is pale yellow in the lower part. The Svea soils are moderately well drained and have high available water capacity. They have a moderately permeable surface layer and subsoil, but permeability of the substratum is moderately slow.

Nearly level Vallers, Tonka, and Parnell soils make up the rest of this association. The Vallers and Tonka soils are poorly drained, and the Parnell soils, in shallow depressions, are very poorly drained.

Soils of this association are slightly to highly susceptible to soil blowing. They are well suited to small grains, hay, and pasture plants, however, and most of the acreage is cultivated. The principal crops are hard red spring wheat and durum wheat. Barley and flax are commonly grown the second year of the cropping system.

2. *Hamerly-Svea-Barnes association*

Deep, nearly level to rolling, somewhat poorly drained to well-drained loamy soils

This association consists of nearly level to rolling soils on uplands in the western part of the county. It occupies about 20 percent of the county.

Nearly level and gently undulating Hamerly soils make up about 30 percent of this association. These soils occupy the lower parts of the landscape. They have a surface layer that is about 14 inches thick and consists of very dark gray, slightly calcareous loam in the upper part and of grayish-brown, strongly calcareous loam in the lower part. Just beneath the surface layer is a layer of pale-yellow clay loam, about 17 inches thick, that contains a large amount of lime. The Hamerly soils are moderately well drained or somewhat poorly drained, and they have high available water capacity. Permeability is moderate in the surface layer and in the limy material, and it is slow in the underlying glacial till.

Svea soils make up about 24 percent of this association. These soils have a surface layer of very dark gray loam about 8 inches thick. Their subsoil is clay loam that is about 11 inches thick and is dark gray in the upper part and grayish brown in the lower part. Just beneath the subsoil is a layer, about 20 inches thick, that contains a large amount of lime. This layer is white clay loam in the upper part and is pale-yellow loam in the lower part. The Svea soils are moderately well drained and have high available water capacity. Permeability is moderate in the surface layer and the subsoil, and it is moderately slow in the substratum.

Gently undulating and rolling Barnes soils make up about 23 percent of this association. These soils have a surface layer of black loam about 8 inches thick. Their subsoil, which is about 11 inches thick, consists of dark-brown clay loam in the upper part and of olive-brown loam in the lower part. Just beneath the subsoil is a layer of pale-olive loam that contains a large amount of lime and is about 18 inches thick. The Barnes soils are well drained and have high available water capacity. They have moderate permeability in the surface layer, in the subsoil, and in the limy material, and they have moderately slow permeability below the limy material.

The rest of this association consists of nearly level Vallers, Tonka, Manfred, and Parnell soils. The Vallers and Tonka soils are poorly drained, and the Manfred and Parnell soils, which are in shallow depressions, are very poorly drained.

Soils of this association are slightly to highly suspectible to soil blowing, and the sloping Barnes soils are also moderately susceptible to water erosion. Most of the soils are well suited to the commonly grown field crops, hay crops, and pasture plants, however, and much of the acreage is cultivated. Hard red spring wheat and durum wheat are the principal crops. Barley and flax are commonly grown the second year of the cropping system. Dairy cattle and feeder cattle are raised on most farms to utilize the hay from areas too wet or too stony for cultivation.

3. *Barnes-Svea-Parnell association*

Deep, nearly level to rolling, well drained and moderately well drained loamy soils and nearly level, deep, very poorly drained loamy and clayey soils

This association consists of soils on complex hills; in concave, shallow swales; and in flat basins that hold water for short periods of time. It occupies about 8 percent of the county and is in the western part.

Barnes soils make up about 53 percent of this association. They have a surface layer of black loam about 8 inches thick (fig. 2). Their subsoil, about 11 inches thick, is dark-brown and very dark gray clay loam in the uppermost 4 inches and is olive-brown loam in the lower part. Just below the subsoil is a layer of pale-olive loam that contains a large amount of lime and is about 18 inches thick. The Barnes soils are well drained and have high available water capacity. They have moderate permeability in the surface layer and the subsoil, and moderately slow permeability in the substratum.

Svea soils make up about 32 percent of this association. These soils have a surface layer of very dark gray loam about 8 inches thick. Their subsoil is about 11 inches thick and is clay loam that is dark gray in the upper part and grayish brown in the lower part. Just beneath the subsoil is a layer, about 20 inches thick, that contains a large amount of lime and consists of white clay loam over pale-yellow loam. The Svea soils are moderately well drained and have high available water capacity. They have moderate permeability in the surface layer and the subsoil and have moderately slow permeability in the substratum.

Parnell soils, which are in depressions, make up about 8 percent of this association. These soils have a surface layer of silty clay loam, about 19 inches thick, that is very dark gray in the upper two-thirds and is dark gray in the lower third. They have a subsoil of dark-gray silty clay about 18 inches thick. The substratum is mottled, gray clay alluvium that ranges from a few inches to several feet in thickness and is underlain by glacial till. The Parnell soils are very poorly drained and have very high available water capacity. Permeability is moderate in the surface

layer, moderately slow in the subsoil, and slow in the substratum.

Nearly level Vallers, Tonka, and Manfred soils, and small areas of gently undulating and strongly rolling Waukon soils make up the rest of this association. The Vallers and Tonka soils are poorly drained; the Manfred soils, in shallow depressions, are very poorly drained; and the Waukon soils are moderately well drained and well drained. The Waukon soils are west of Edinburg.

Most soils of this association are slightly susceptible to soil blowing, and in most places the soils are also moderately susceptible to water erosion. Most of the acreage is cultivated, however, and the soils are well suited to hard wheat, durum wheat, barley, flax, and the commonly grown hay crops and pasture plants. Dairy cattle and feeder cattle are raised on many farms to utilize the forage from the hay crops and pastures.

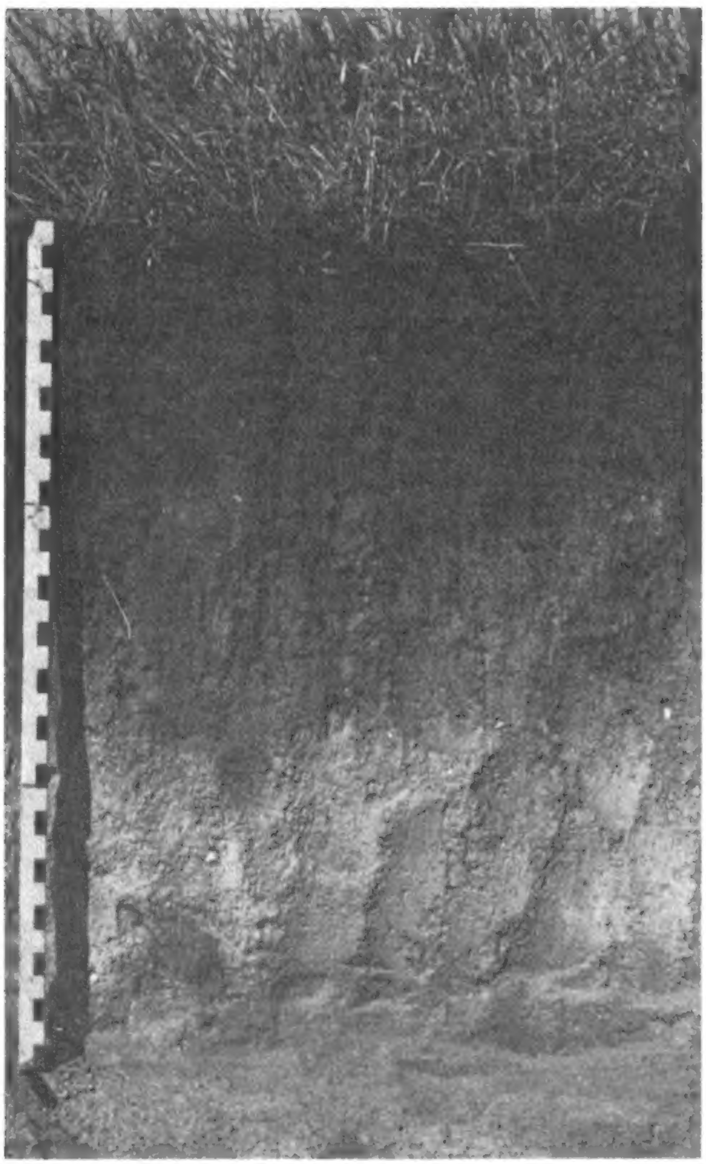

***Figure 2.*—Profile of a Barnes loam under native grass.**

4. Svea-Barnes association

Deep, nearly level and gently sloping, moderately well drained and well drained loamy soils

This association is in the west-central part of the county. It consists of a part of the glacial till plain where the soils are nearly level and slope very gently toward the east. The association is dissected by many shallow drainageways, and it contains a few depressions. It occupies about 3 percent of the county.

Svea soils make up about 70 percent of this association. These soils have a surface layer of very dark gray loam about 8 inches thick. Their subsoil is about 11 inches thick. It is dark-gray clay loam in the upper part and grades to grayish-brown clay loam in the lower part. Below the subsoil is a layer, about 20 inches thick, that contains a large amount of lime and consists of white clay loam over pale-yellow loam. The substratum is calcareous loam glacial till. The Svea soils are moderately well drained and have high available water capacity. They have moderate permeability in the surface layer and the subsoil and moderately slow permeability in the substratum.

Barnes soils make up about 25 percent of this association. They have a surface layer of black loam about 8 inches thick. Their subsoil is about 11 inches thick and is dark-brown and very dark gray clay loam in the upper part and olive-brown loam in the lower part. Just below the subsoil is a layer of pale-olive loam that is about 18 inches thick and contains a large amount of lime. This layer is underlain by calcareous glacial till. The Barnes soils are well drained and have high available water capacity. They have moderate permeability in the surface layer and the subsoil, and moderately slow permeability in the substratum.

Some minor areas of this association are occupied by moderately well drained Cresbard, poorly drained Tonka, and very poorly drained Parnell soils. Other minor areas are occupied by stony Barnes and Svea soils.

Soils of this association are slightly susceptible to soil blowing and water erosion. They are used mainly for cultivated crops but are well suited to the commonly grown field crops, hay crops, and pasture plants. Hard red spring wheat and durum wheat are the principal crops. Barley and flax are commonly grown the second year of the cropping system.

5. Barnes-Buse association

Deep, gently undulating to steep, well-drained and excessively drained loamy soils on the Edinburg moraine

This association consists mainly of gently undulating to hilly Barnes soils and of rolling to steep Buse soils. It contains many shallow depressions. The association occupies about 2 percent of the county and is in the central part.

Barnes soils make up about 55 percent of this association. These soils have a surface layer of black loam about 8 inches thick. They have a subsoil that is about 11 inches thick and consists of dark-brown and very dark gray clay loam in the upper part and of olive-brown loam in the lower part. Below the subsoil is a layer, about 18 inches thick, of pale-olive loam that contains a large amount of lime and is underlain by calcareous glacial till. The Barnes soils are well drained and have high available water capacity. They have moderate permeability in the surface

layer, in the subsoil, and in the layer that contains a large amount of lime, and they have moderately slow permeability in the underlying glacial till.

Buse soils make up about 30 percent of this association. These soils have a surface layer of dark-gray loam about 7 inches thick. Just beneath the surface layer is a layer of light-gray loam that contains a large amount of lime and is about 16 inches thick. Below the layer of limy material is calcareous loam or clay loam glacial till. These soils are excessively drained and have high available water capacity. They have moderately slow permeability.

Very poorly drained Parnell soils, poorly drained Tonka soils, and moderately well drained Svea and Embden soils make up the rest of this association. The Parnell and Tonka soils are in depressions, and the Svea and Embden soils are in nearly level or slightly concave areas.

Soils of this association are slightly to highly susceptible to water erosion and soil blowing. They are suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. Hard red spring wheat and durum wheat are the prinicipal crops, and barley and flax are commonly grown the second year of the cropping system. Areas too steep or too stony for cultivation have been left in native grass that is used for hay or pasture.

6. *Kloten-Edgeley association*

Shallow to deep, nearly level to undulating and steep, well-drained loamy soils over shale bedrock

This association consists mainly of sloping and steep Kloten soils that are shallow over shale bedrock, and of the adjacent, nearly level and undulating Edgeley soils that are deep over shale bedrock. The soils are on the side slopes of stream valleys that cut through the glacial till plains in the northern part of the county west of Edinburg. The association occupies about 2 percent of the county.

Kloten soils make up about 53 percent of this association. They have a surface layer of very dark gray loam about 5 inches thick. In wooded areas the surface layer is covered by a thin layer of leaf litter. Just below the surface layer is a layer of gray clay loam glacial till about 8 inches thick. Beneath the till is gray, bedded shale that is partly weathered in the uppermost 17 inches. The Kloten soils are well drained. Permeability is moderate in the surface layer, moderately slow between the surface layer and the shale, and very slow in the shale. Above the shale, the available water capacity is high, but in the shale it is very low.

Edgeley soils make up about 41 percent of this association. These soils have a surface layer of very dark gray loam about 5 inches thick. Their subsoil is about 20 inches thick and consists of dark grayish-brown clay loam in the upper part and of olive-gray shaly clay loam in the lower part. Below the subsoil is light olive-gray shaly clay loam glacial till that is underlain by bedded shale at a depth of about 46 inches. The Edgeley soils are well drained and have high available water capacity. They have moderate permeability in the surface layer and the subsoil and moderately slow permeability in the substratum.

Minor soils make up the rest of this association. They are the moderately well drained Cresbard and Svea soils; the somewhat poorly drained Cavour soils and the Bearden soils that have a gravelly substratum; and the poorly drained Lamoure soils.

Soils of this association are slightly susceptible to soil blowing and are slightly to highly susceptible to water erosion. The soils in about half of the association are cultivated and are suited to the commonly grown field crops, hay crops, and pasture plants. Hard red spring wheat and durum wheat are the principal crops. Barley and flax are generally grown the second year of the cropping system. Dairy cattle and feeder cattle are raised on most farms. They utilize the forage from areas where the soils are too steep or too stony for cultivation and are used as woodland, for pasture, or for hay crops.

7. *Buse-Fairdale association*

Deep, nearly level to steep, excessively drained and moderately well drained loamy soils

This soil association is in the south-central part of the county. It occupies about 1 percent of the total acreage in the county.

Rolling to steep Buse soils make up about 55 percent of this association. These soils have a surface layer of dark-gray loam about 7 inches thick. The surface layer is underlain by a layer of light-gray loam that contains a large amount of lime and is about 16 inches thick. Beneath the limy material is loamy, calcareous glacial till. The Buse soils are excessively drained, and they have high or very high available water capacity. They have moderately slow permeability throughout.

Fairdale soils, on the flood plains of streams, make up about 30 percent of this association. These soils have a surface layer of grayish-brown silt loam about 3 inches thick that is covered by an accumulation of leaf litter in wooded areas. Just below the surface layer is stratified, calcareous material that is variable in color, texture, and thickness. This stratified material generally contains one or more dark-gray or black layers that are the surface layers of buried soils. The Fairdale soils are moderately well drained and have high available water capacity. They have moderate or moderately slow permeability, depending on the texture of the various layers.

Embden and Sioux soils make up the rest of this association. The Embden soils are moderately well drained, and the Sioux soils are excessively drained.

The Fairdale soils are only slightly susceptible to soil blowing, but the Buse and Embden soils are moderately to highly susceptible. A small part of the acreage of Fairdale and Embden soils is suited to the commonly grown small grains, hay crops, and pasture plants, however, and that acreage is generally cultivated. The rest of the association is mainly in native timber. It is well suited to use as habitat for most of the common species of wildlife.

Soils of the Outwash, Interbeach, Delta, and Valley Areas

Soils of this group occupy a belt, approximately 6 to 14 miles wide, that extends in a north-south direction across the central part of Walsh County. The soils lie east of the glacial till plain. They have formed in sandy, gravelly, and loamy material that was carried by glacial melt water into glacial Lake Agassiz and was deposited as deltas, fans,

beaches, interbeach areas, and offshore bars. Some of the soils have formed in outwash that was deposited in areas adjacent to the uplands on the western edge of the lake areas. Others have formed in material deposited by glacial streams in old valleys. Still others have formed in lake-washed glacial till that lies between the beaches. Four soil associations are in this group.

8. *Renshaw-Brantford-Sioux association*

Shallow, nearly level to steep, excessively drained and well-drained loamy soils underlain by sand and gravel

This association consists of shallow loamy soils that are mainly on glacial outwash plains. It includes some sloping, gravelly soils on lake beach lines. Most of the soils on outwash plains are nearly level to sloping, but some steep soils are on the ridges and side slopes of entrenched streams. This association occupies about 3 percent of the county. It is mostly in the south-central part of the county, but one area lies north of Edinburg.

Renshaw soils make up about 35 percent of this association. They have a surface layer of very dark brown loam about 6 inches thick. Their subsoil is about 12 inches thick and is very dark grayish-brown sandy clay loam in the upper part and very dark grayish-brown gravelly loam in the lower part. The substratum is calcareous in the upper part, and it consists of coarse sand and gravel. The Renshaw soils are excessively drained. They have moderate permeability and high available water capacity in the surface layer and the subsoil. They have rapid permeability and very low available water capacity in the substratum.

Brantford soils make up about 29 percent of this association. These soils have a surface layer of very dark gray loam about 6 inches thick. They have a loam subsoil about 14 inches thick that is grayish brown in the upper part and is light brownish gray in the lower part. The substratum consists of light olive-gray sand and gravel derived from shale. The Brantford soils are well drained. Their surface layer and their subsoil have moderate permeability and high available water capacity. Their substratum has rapid permeability and very low available water capacity.

Sioux soils make up about 12 percent of this association. They have a surface layer that is about 8 inches thick and is very dark gray gravelly loam in the upper part and is dark-brown loam in the lower part (fig. 3). The surface layer is underlain by beds of stratified gravel and sand. The Sioux soils are excessively drained. Their surface layer is moderately permeable and has moderate available water capacity. Their substratum is rapidly permeable and has very low available water capacity.

Minor soils of this association are the nearly level and gently sloping Arvilla, the sloping to steep Coe, the nearly level to sloping Vang, and the nearly level, moderately well drained and somewhat poorly drained Divide soils.

Soils of this association are moderately to highly susceptible to soil blowing. They are suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. Hard red spring wheat and durum wheat are the principal crops, and barley and flax are commonly grown the second year of the cropping system. Dairy cattle and feeder cattle are raised on most farms to utilize the forage from hay and pasture crops grown on areas too steep for cultivation.

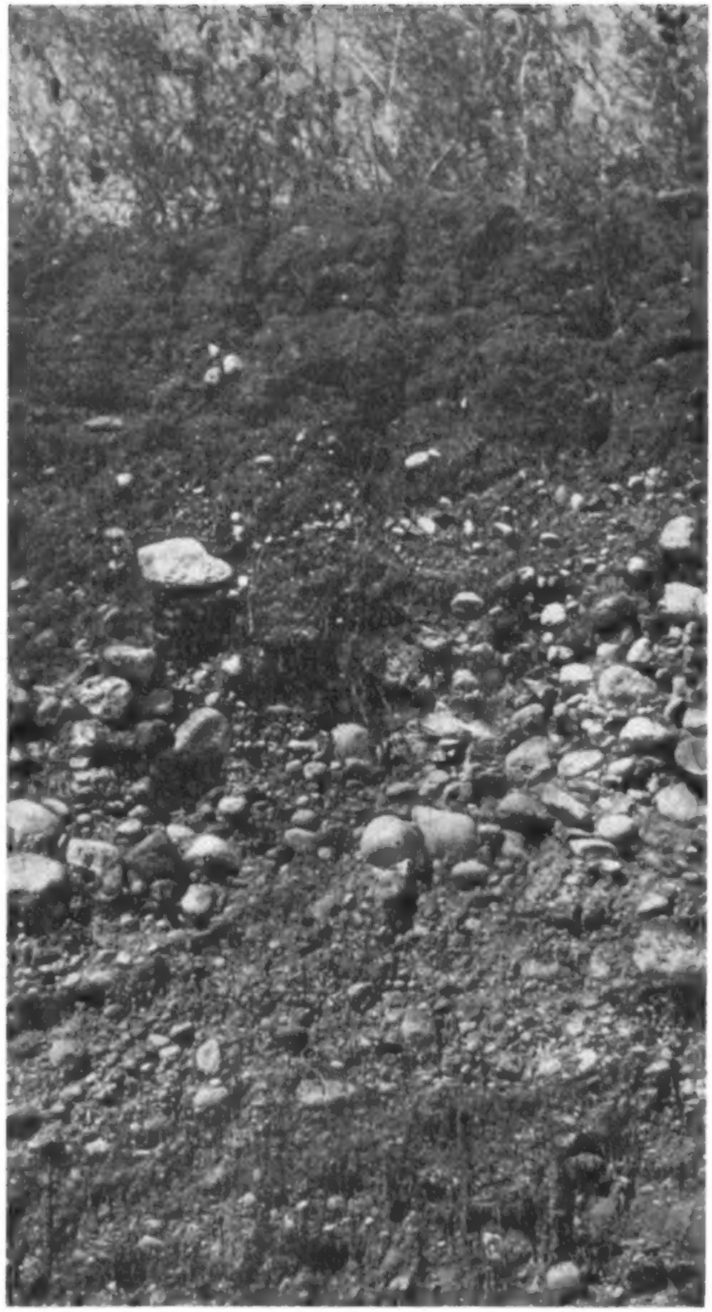

***Figure 3.*—Profile of Sioux gravelly loam under native vegetation.**

9. *Embden-Hecla-Ulen association*

Deep, nearly level to sloping, moderately well drained and somewhat poorly drained loamy and sandy soils

This association consists of nearly level to sloping soils in areas that extend through the central part of Walsh County. The soils occupy a plain that is dissected by many intermittent drainageways, which carry runoff that flows in an easterly direction. Many springs originate in this association. Some parts of the association contain stabilized sand dunes and shallow blowout areas, and a few areas contain active sand dunes. This association occupies about 4 percent of the county.

Nearly level to sloping Embden soils make up about 44 percent of this association. They have a surface layer of very dark gray sandy loam about 11 inches thick. Their subsoil is about 13 inches thick and consists of fine sandy loam that is dark gray in the upper part and brown in the lower part. Just below the subsoil is a layer of light-gray loamy sand that contains a large amount of lime and is about 20 inches thick. The Embden soils are moderately well drained. They have moderate to high available water capacity in the surface layer and the subsoil and low available water capacity in the substratum. Permeability is moderately rapid.

Nearly level and gently undulating Hecla soils occupy about 28 percent of this association. These soils have a surface layer of loamy sand that is about 32 inches thick and is very dark gray in the upper part, very dark grayish brown in the middle part, and dark grayish brown in the lower part. Just below the surface layer is light yellowish-brown sand that extends to a depth of 40 inches or more. The Hecla soils are moderately well drained. They have moderate available water capacity in the surface layer, and low available water capacity in the substratum. Permeability is moderately rapid above the glacial till, but it is slow in the till.

Nearly level and gently sloping Ulen soils make up about 15 percent of this association. These soils have a surface layer that is about 15 inches thick and is black sandy loam in the upper part and very dark gray fine sandy loam in the lower part. Just below the surface layer is a layer of strongly calcareous loam that contains a large amount of lime and is about 17 inches thick. This layer is light gray in the upper part and is white mottled with light olive brown in the lower part. Underlying the layer of limy material is stratified, mottled, sandy sediment. The Ulen soils are moderately well drained or somewhat poorly drained. Permeability is moderate in the surface layer and in the layer where lime has accumulated, and it is moderately rapid in the layers below. The available water capacity is moderate.

Minor soils make up the remaining 13 percent of this association. They are the well-drained Maddock, the somewhat poorly drained and poorly drained Hamar, and the poorly drained Arveson and Fossum soils.

Soils of this association are highly or very highly susceptible to soil blowing (fig. 4). The soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. Hard red spring wheat and durum wheat are the principal crops, and they are commonly followed the second year of the cropping system by barley and flax. In addition, potatoes are grown on some areas of Embden soils. Dairy cattle and feeder cattle are raised on some farms to utilize the hay grown where the soils are too wet or too sandy for cultivation.

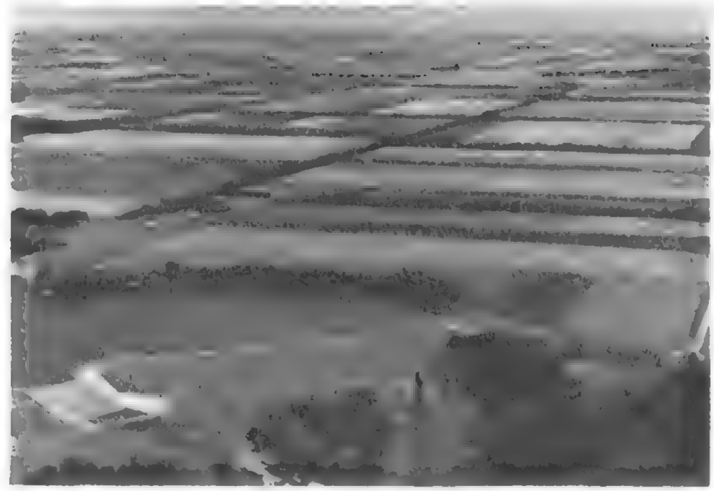

Figure 4.—**Multiple-row field windbreaks, established on Embden and Hecla soils of association 9 as part of the Park River Demonstration Project. These windbreaks help to protect the soils from blowing. Cottonwood trees in the center of the windbreaks had an average height of 70 feet at the end of 25 years. Homme Dam and reservoir are in the foreground.**

10. Lankin-Gilby association

Deep, nearly level to gently sloping, somewhat poorly drained and poorly drained loamy soils

This association consists of deep, nearly level and gently sloping loamy soils that occupy interbeach areas in the central part of the county (fig. 5). It is on a plain that is marked by several beach lines and deltas and by many shallow depressions. The association is dissected by many intermittent drainageways, which in spring carry runoff that flows in an easterly direction. It comprises about 9 percent of the county.

Nearly level and gently sloping Lankin soils make up about 46 percent of this association. These soils have a surface layer of very dark gray loam that is about 7 inches thick. Their subsoil is dark-gray loam about 9 inches thick. Just beneath the subsoil is a layer of clay loam, about 18 inches thick, that is white in the upper part and light gray in the lower part and contains a large amount of lime. Below this limy material is calcareous, light olive-gray, loamy glacial till mottled with olive gray. The Lankin soils are somewhat poorly drained and have high available water capacity. They have moderate permeability in the surface layer and the subsoil and moderately slow permeability in the glacial till substratum.

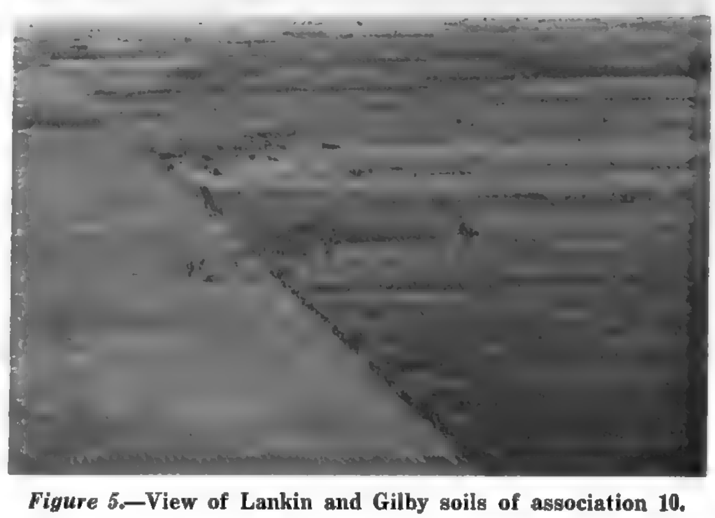

Figure 5.—**View of Lankin and Gilby soils of association 10.**

Nearly level Gilby soils make up about 35 percent of this association. These soils have a surface layer that is about 10 inches thick and is calcareous loam that is very dark gray in the upper part and is dark gray in the lower part. Just below the surface layer is a layer of clay loam, about 14 inches thick, that contains a large amount of lime. This limy material is light gray in the upper part and is pale yellow mottled with yellowish brown in the lower part. The lower part consists of glacial till in some places. It is underlain by pale-yellow, light olive-brown, olive-gray, and light brownish-gray, calcareous, loamy glacial till. The Gilby soils are somewhat poorly drained or poorly drained, and they have high available water capacity. Permeability is moderate above the glacial till, and it is moderately slow in the till.

About 19 percent of this association consists of moderately well drained Towner, somewhat poorly drained Antler, and poorly drained Rockwell and Tonka soils.

The Lankin soils are slightly succeptible and the other soils are moderately to highly susceptible to soil blowing. Field windbreaks have been planted on a large acreage to help to control soil blowing.

The soils in most of this association are well suited to the field crops, hay crops, and pasture plants commonly grown in the county. Hard red spring wheat and durum wheat are the principal crops. Barley and flax are commonly grown the second year of the cropping system, and potatoes are grown in some places on the Lankin, Towner, and Rockwell soils. Soils that are too stony or too wet for cultivation are used for native hay or pasture.

11. Walsh association

Deep, level to sloping, well drained and moderately well drained loamy soils formed in shaly alluvium

This association lies west of Park River in a valley that slopes to the south and is 2 to 4 miles wide. It consists of deep loamy soils that are nearly level to sloping. The association occupies about 1 percent of the county.

Walsh soils that have a surface layer of silt loam make up about 60 percent of this association. The surface layer of these soils is very dark gray and is about 10 inches thick. Their subsoil is gray silty clay loam about 12 inches thick. The substratum is shaly alluvial material that is gray silty clay loam in the upper part, light brownish-gray silty clay loam in the middle part, and gray loam in the lower part. These soils are well drained and moderately well drained, and they have high available water capacity. Permeability is moderate in the surface layer, and it is moderately slow in the subsoil and the substratum.

Walsh soils that have a surface layer of clay loam make up about 30 percent of this association. They have a profile similar to the Walsh silt loams, except for the texture of their surface layer.

Sloping Walsh soils that have a surface layer of loam, and other Walsh soils that also have a surface layer of loam and a sand substratum, make up the rest of this association. These soils have a profile similar to that of the Walsh silt loams, except that their surface layer is loam and they contain more coarse material.

Soils of this association are moderately to highly susceptible to soil blowing. They are well suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. Hard red spring wheat and durum wheat are the principal crops. Barley and flax are commonly grown the second year of the cropping system. Potatoes are a minor, but an important, crop. Some corn is grown as feed for dairy cattle.

Soils of the Glacial Lake Plain

Soils of the glacial lake plain are in the eastern half of Walsh County. The areas are mostly nearly level, but they contain low ridges and shallow depressions in which differences in elevation between the highest and the lowest points is only 1 to 2 feet. Water floods some of these areas when snow melts rapidly, when streams overflow, or when heavy rainfall occurs. Streams that flow from the glacial till plain to the west discharge their water onto the lake plain. As a result, deltas have formed in places. Some deltas were formed when this area was still covered by a glacial lake. The native vegetation was tall prairie grasses.

The delta and lake sediment of very fine sand, silt, and silty clay loam was deposited mainly in the western part of the lake plain. The lake sediment of clay and silty clay was deposited mainly in the eastern part of the plain, where the decrease in slope amounts to only a few feet per mile. Seven soil associations are in this group.

12. Glyndon-Gardena association

Deep, nearly level to gently sloping, moderately well drained and somewhat poorly drained loamy soils

This association is on the glacial lake plain in the eastern part of the county. It is dissected by many intermittent streams that drain in an easterly direction. Nearly level and gently sloping Glyndon and Gardena soils occupy most of the acreage. The nearly level Glyndon soils are on ridges that are only a few inches to a foot or more in height and that are separated by shallow depressions. The gently sloping Glyndon soils are on the side slopes of drainageways. The Gardena soils are nearly level. They are on the part of the lake plain where there are only a few depressions. This association occupies about 13 percent of the county.

Glyndon soils make up about 73 percent of this association. They have a surface layer of very dark gray, calcareous silt loam about 8 inches thick. Just below the surface layer is a layer of gray, strongly calcareous silt loam that is about 20 inches thick and contains a large amount of lime. The limy material is underlain by stratified, light yellowish-brown and light olive-brown very fine sandy loam that is mottled with gray. The Glyndon soils are moderately well drained or somewhat poorly drained. They have high available water capacity and are moderately permeable throughout.

Gardena soils make up about 14 percent of this association. These soils have a surface layer of dark-gray silt loam about 11 inches thick. The subsoil is about 16 inches thick. It consists of very dark grayish-brown silt loam in the upper part and of grayish-brown, calcareous very fine sandy loam in the lower part. The substratum is pale-olive very fine sandy loam that contains a large amount of lime. The Gardena soils are moderately well drained and have high available water capacity. They are moderately permeable throughout.

Borup, Colvin, and Perella soils make up the rest of this association. All of these soils are poorly drained.

Soils of this association are moderately to highly susceptible to soil blowing. They are well suited to potatoes, sugar beets, small grains, hay, and pasture plants, however, and most of the acreage is cultivated (fig. 6). Potatoes are the principal crop. Hard red spring wheat and durum wheat are the principal small grains. Barley and flax are commonly grown the second year of the cropping system.

13. Bearden-Overly association

Deep, nearly level to gently sloping, somewhat poorly drained and moderately well drained silty soils

This association is in the eastern part of the county. It contains many intermittent streams that flow in an easterly direction. Part of the association consists of nearly level Bearden soils that occur on the part of the lake plain where the ridges are only a few inches higher than the intervening shallow depressions. Other areas consist of nearly level and gently sloping Overly soils on the part of the lake plain that contains a few depressions. Still other areas consist of gently sloping Overly soils on the side slopes of drainageways. The association occupies about 12 percent of the county.

Bearden soils make up about 65 percent of this association. They have a surface layer of black silty clay loam, about 9 inches thick, that is slightly calcareous in the upper part but is more calcareous in the lower part. The surface layer has an irregular boundary, and tongues of material from this layer extend downward into the layer below. Just beneath the surface layer is a layer of grayish-brown silty clay loam that contains a large amount of lime and is about 11 inches thick. The limy material is underlain by light olive-brown silty clay loam mottled with gray, white, and brown. The Bearden soils are somewhat poorly drained and have very high available water capacity. They have moderately slow permeability throughout.

Overly soils make up about 28 percent of this association. They have a surface layer of very dark gray silty clay loam about 10 inches thick. Their subsoil is about 10 inches thick and is silty clay loam or silty clay that is dark gray in the upper part and is grayish brown in the lower part. Below the subsoil is a layer of silty clay loam that is about 18 inches thick and contains a large amount of lime. This limy material is underlain by light olive-brown and pale-olive, stratified, moderately fine textured and fine textured lake sediment. The Overly soils are moderately well drained and have high available water capacity. They have moderate to moderately slow permeability in the surface layer and the subsoil, and they have moderately slow or slow permeability in the layer that contains a large amount of lime and in the substratum. The fine-textured layers in the substratum are slowly permeable.

Colvin, Perella, and Fargo soils make up the rest of this association. All of these soils are poorly drained.

Figure 6.—**Farmstead on Glyndon and Gardena soils of association 12.**

The soils of this association are well suited to the field crops, hay crops, and pasture plants commonly grown in the county, but most of them are moderately to highly susceptible to soil blowing. A large part of the acreage is cultivated. Hard red spring wheat, durum wheat, and barley are the principal crops, but potatoes and sugar beets are also grown extensively. Flax is an important crop on the Overly soils.

14. Bearden-Glyndon association

Deep, nearly level, moderately well drained and somewhat poorly drained, calcareous clayey and loamy soils

This association consists of nearly level soils on the part of the lake plain where depressions are few. The association occupies about 1 percent of the county and is in the northeastern and southeastern parts.

Bearden soils make up about 70 percent of this association. They have a surface layer of black silty clay that is about 9 inches thick. The surface layer contains some lime, but the lower part contains more lime than the upper part. The surface layer has an irregular boundary, and tongues of material from that layer extend downward into the layer below. The next layer is grayish-brown silty clay loam that is about 11 inches thick and contains a large amount of lime. Just below this layer is the substratum, which is dominantly light olive-brown silty clay loam that is mottled with gray, white, and brown. The Bearden soils are somewhat poorly drained and have very high available water capacity. They have moderately slow permeability.

Glyndon soils make up about 26 percent of this association. They have a surface layer of very dark gray silt loam about 8 inches thick. Just below the surface layer is a layer of gray silt loam that is about 20 inches thick and contains a large amount of lime. Underlying this limy material is stratified, light yellowish-brown and light olive-brown very fine sandy loam that is mottled with gray. The Glyndon soils are moderately well drained or somewhat poorly drained, and they have high available water capacity. They are moderately permeable.

Perella soils and moderately saline Bearden and Glyndon soils make up the remaining 4 percent of this association. The Perella soils are poorly drained.

Soils of this association are moderately to highly susceptible to soil blowing. They are well suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. Hard red spring wheat, durum wheat, and sugar beets are the principal crops, but potatoes and barley are also grown extensively.

15. Overly-Bearden fans association

Deep, nearly level, moderately well drained and somewhat poorly drained silty and clayey soils on alluvial fans

This association occupies alluvial fans on the lake plain in the east-central part of the county. The areas are nearly level, contain few depressions, and are traversed by old abandoned stream channels, as well as by present-day drainageways. The soils commonly contain a very dark colored buried horizon, which indicates the thickness and the extent of the alluvial deposits. This association occupies about 2 percent of the county.

Overly soils make up about 64 percent of this association. These soils have a surface layer of very dark gray silty clay loam or silty clay about 10 inches thick. Their subsoil, also about 10 inches thick, is silty clay loam that is dark gray in the upper part and is grayish brown in the lower part. The lower part of the subsoil contains a large amount of lime. Just below the subsoil is a layer of silty clay loam that also contains a large amount of lime and is about 18 inches thick. Underlying this layer is light olive-brown and pale-olive, stratified, moderately fine textured and fine textured sediment. The Overly soils are moderately well drained, have high or very high available water capacity, and have moderate to slow permeability. Where permeability is slow, the soil material is finer textured than where permeability is moderate.

Bearden soils make up about 26 percent of this association. These soils have a surface layer of black silty clay loam that is slightly limy and is about 9 inches thick. The lower part of the surface layer contains more lime than the upper part, and it has an irregular boundary. Tongues of material from the surface layer extend downward into the layer below. The layer just beneath the surface layer is grayish-brown silty clay loam that is about 11 inches thick and contains a large amount of lime. Underlying the limy material is a layer that is dominantly light olive-brown silty clay loam mottled with gray, white, and brown. The Bearden soils are somewhat poorly drained, have very high available water capacity, and have moderately slow permeability.

The rest of this association consists of moderately well drained Fairdale and LaPrairie soils. These soils are on stream levees and on channeled bottom lands.

Soils of this association are moderately to highly susceptible to soil blowing. They are well suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. Hard red spring wheat, potatoes, durum wheat, and barley are the principal crops, but sugar beets and flax are also grown.

16. Bearden-Glyndon moderately saline association

Deep, nearly level, somewhat poorly drained and moderately well drained silty and loamy soils that are saline

This association occupies about 1 percent of Walsh County. It is in the eastern part.

Saline Bearden soils make up about 75 percent of this association. These soils have a surface layer of black, slightly calcareous silty clay loam about 9 inches thick. The lower part of the surface layer contains more lime than the upper part, and it has an irregular boundary. Tongues of material from the surface layer extend downward into the layer below. The layer just below the surface layer is grayish-brown silty clay loam that contains a large amount of lime and is about 11 inches thick. Underlying this layer is the substratum, which is dominantly light olive-brown silty clay loam mottled with gray, white, and brown. These saline Bearden soils have nests of gypsum and other salts throughout their profile. They are somewhat poorly drained, have moderately slow permeability, and have high available water capacity.

Moderately saline Glyndon soils make up about 16 percent of this association. These soils have a surface layer

of very dark gray, calcareous silt loam about 8 inches thick. Just below the surface layer is a layer of gray silt loam that contains a large amount of lime and is about 20 inches thick. The substratum is stratified, light yellowish-brown and light olive-brown very fine sandy loam that is mottled with gray. The Glyndon soils also have nests of gypsum and other salts throughout their profile. They are moderately well drained or somewhat poorly drained, have high available water capacity, and have moderate permeability.

The rest of this association consists of poorly drained Colvin and Perella soils, and of areas of nonsaline Bearden and Glyndon soils.

Soils of this association are moderately to highly susceptible to soil blowing. Most of the acreage is cultivated, however, although all the crops grown are adversely affected by the salinity of the soils. Barley, sugar beets, and hard red spring wheat are the principal crops.

17. Hegne-Fargo association

Deep, nearly level to gently sloping, poorly drained clayey soils

This association is in the eastern part of the county. It consists mainly of nearly level and gently sloping Hegne and Fargo soils. The Hegne soils are on ridges that are only a few inches above the level of the lake plain. They are also in shallow depressions between the ridges and on the side slopes of drainageways. The Fargo soils are in shallow depressions, in nearly level areas, and on the side slopes of drainageways and of levees along streams. This association occupies about 11 percent of the county.

Hegne soils make up about 74 percent of this association. These soils have a surface layer of very dark gray silty clay about 14 inches thick. The surface layer is slightly calcareous in the upper part, and it has a large amount of lime in the lower part. Just below the surface layer is a layer that contains a large amount of lime and is about 17 inches thick. This layer is gray silty clay loam in the upper part and is pale-yellow silty clay in the lower part. The substratum consists of mottled, calcareous, fine-textured lacustrine sediment. The Hegne soils are poorly drained and have very high available water capacity. They have moderate permeability in the surface layer, and moderately slow or slow permeability in the layers below the surface layer.

Fargo soils make up about 20 percent of this association. These soils have a surface layer of black silty clay about 9 inches thick. The subsoil is about 13 inches thick, and it consists of silty clay that is black in the upper part and very dark gray in the lower part. The substratum is fine-textured, stratified lacustrine sediment. The Fargo soils are poorly drained, have high or very high available water capacity, and have slow permeability.

The rest of this association consists of poorly drained and very poorly drained Grano soils.

The soils throughout most of this association are moderately to highly susceptible to soil blowing. They are suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. Hard red spring wheat, durum wheat, and barley are the principal crops. Flax, sugar beets, and potatoes are also grown.

18. Ojata-Hegne saline association

Deep, nearly level, poorly drained silty and clayey soils that are strongly saline.

This association consists of saline soils that surround saline lakes and of other saline soils on bottom lands along streams. It occupies about 1 percent of the county and is in the eastern part.

Ojata soils make up about 39 percent of this association. These soils have a surface layer of very dark gray, calcareous silty clay loam about 5 inches thick. In many places the surface layer is bare of vegetation and is covered by a thin accumulation of white salt. Just below the surface layer is a layer of dark-gray, mottled, strongly calcareous silty clay loam that is about 7 inches thick and contains a large amount of lime. Underlying this layer is a layer of dark grayish-brown, calcareous silty clay loam sediment that is mottled with brown and gray. The Ojata soils are strongly saline and have nests of gypsum and other salts throughout their profile. They are poorly drained, have high available water capacity, and have moderately slow or slow permeability.

Moderately to strongly saline and alkali Hegne soils make up about 23 percent of this association. The surface layer of these soils is very dark gray silty clay that is about 14 inches thick. It is slightly calcareous in the upper part and has a large amount of lime in the lower part. Just below the surface layer is a layer of gray silty clay that contains a large amount of lime and is about 16 inches thick. The substratum is mottled, calcareous, fine-textured lacustrine sediment. The moderately to strongly saline and alkali Hegne soils have nests of gypsum and other salts throughout their profile. They are poorly drained and have very high available water capacity. Permeability is moderate in the surface layer. It is moderately slow or slow in the layers below the surface layer.

The rest of this association consists of poorly drained Colvin and Ryan soils, of very poorly drained Ludden soils, and of Lake Ardoch and two salt lakes.

Most of this association has a cover of salt-tolerant and alkali-tolerant grasses, and it is used for hay or pasture. The soils are moderately to highly susceptible to soil blowing if they are cultivated. The moderately saline Hegne soils are suited only to native grass and to barley, sugar beets, and other crops that are tolerant of salt. Wheat and flax are grown on nonsaline areas.

Soils of the Flood Plains and Low Terraces

Soils of flood plains and low terraces are along the Red, Forest, and Park Rivers in the eastern part of the county. They are nearly level. Some of these soils are on bottom lands that are flooded for a short time nearly every year. Others are on levees on the first terraces above the flood plains. A few areas are dissected by numerous stream channels.

The soils have formed in stratified, recently deposited alluvium that ranges from light loam to clay in texture. On the flood plains, the native vegetation was deciduous trees, shrubs, and tall grasses. On the levees, it was tall prairie grasses. Two soil associations are in this group.

19. Fairdale-LaPrairie association

Deep, nearly level to gently sloping, moderately well drained loamy soils on flood plains

This association consists of soils on flood plains. It occupies about 2 percent of the county.

Fairdale soils make up about 55 percent of this association. These soils have a surface layer of grayish-brown silt loam about 3 inches thick. The surface layer is underlain by stratified, calcareous material that is variable in color, texture, and thickness. In most places the soils contain one or more layers that are dark gray to black, and these layers are the surface layer of a buried soil. Where the soils are under timber, a layer of leaf litter covers the surface. The Fairdale soils are moderately well drained and have high available water capacity. Permeability is moderate or moderately slow, depending on the texture of the deposited sediment.

LaPrairie soils make up about 38 percent of this association. These soils have a surface layer of dark-gray silt loam about 7 inches thick. The subsoil is about 27 inches thick and is dark grayish-brown silt loam in the upper part and brown silty clay loam in the lower part. The subsoil is underlain by stratified brown silt loam and silty clay loam. The LaPrairie soils are moderately well drained and have high available water capacity. Permeability is moderate in the layers of silt loam, and it is moderately slow in the finer textured material.

The rest of this association consists of somewhat poorly drained Bearden soils that have a gravelly substratum, and of very poorly drained Rauville soils.

Soils of this association are slightly susceptible to soil blowing, and flooding is common in spring. About half of the association is cultivated, and the rest is in native timber. The cultivated soils are well suited to the commonly grown field crops, hay crops, and pasture plants. The principal crops are hard red spring wheat, potatoes, durum wheat, and barley, but sugar beets and flax are also grown on a large acreage. The areas in native timber are well suited to use as habitat for most of the common species of wildlife.

20. Wahpeton-Cashel-Fargo association

Deep, nearly level to gently sloping, moderately well drained to poorly drained clayey soils on flood plains and low terraces

This association occupies a narrow area along the Red River. It consists of Cashel soils on the first flood plain of the Red River; of Wahpeton soils on the natural levees of the Red River and its major tributaries; and of Fargo soils that are adjacent to the natural levees. These soils are all predominantly nearly level or gently sloping, but there are some areas of steep Cashel soils on the banks of the Red River. The association occupies about 2 percent of the county.

Wahpeton soils make up about 59 percent of this association. These soils have a surface layer of very dark gray silty clay about 7 inches thick. Just below the surface layer is a series of dark gray and very dark gray layers that are the surface layers of buried soils. The Wahpeton soils are moderately well drained. They have very high available water capacity and moderate or moderately slow permeability.

Cashel soils make up about 25 percent of this association. They have a surface layer of gray, slightly calcareous silty clay about 8 inches thick. The material below the surface layer is stratified and consists of gray or grayish-brown, fine-textured flood plain deposits. Most profiles contain one or more horizons that are the surface layer of a buried soil. The Cashel soils are somewhat poorly drained and have high available water capacity. Permeability is moderately slow.

Fargo soils make up about 16 percent of this association. These soils have a surface layer of black silty clay about 9 inches thick. Their subsoil is about 13 inches thick, and it is black silty clay in the upper part and is very dark gray silty clay in the lower part. The substratum consists of thin layers of fine-textured lacustrine sediment. The Fargo soils are poorly drained and have high available water capacity. Permeability is moderately slow or slow.

In years when the amount of runoff is above normal in spring, soils of this association are subject to flooding. The soils are moderately to highly susceptible to soil blowing. About 80 percent of the acreage is cultivated. The rest, along the Red River, is in native timber. Most of the soils are well suited to the field crops, hay crops, and pasture plants commonly grown in the county. Hard red spring wheat, durum wheat, and barley are the principal crops. Sugar beets are also grown extensively, and some potatoes are grown. The noncultivated areas provide fair to good habitat for most of the common species of wildlife.

Descriptions of the Soils

In this section the soils of Walsh County are described in detail. The procedure is to describe first the soil series, and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read both the description of that unit and the description of the soil series to which the unit belongs. The approximate acreage and proportionate extent of the mapping units are given in table 1.

Each series description contains a short description of a typical soil profile and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations.

The detailed description of the profile is considered representative of all the mapping units in that series. If the profile of a given mapping unit differs from this typical profile, the differences are stated in the description of the mapping unit, unless they are apparent from the name of the mapping unit.

A single area of one kind of soil may contain inclusions of more than 15 percent of another soil, but the total area of the kind of soil likely would include no more than 15 percent of soils other than those for which the mapping unit is named.

In the detailed descriptions of typical profiles, references to color apply to dry soil, except as otherwise specifically noted. Many of the terms used in describing the soil series and mapping units are defined in the Glossary, and some of the commonly used terms are explained in the section "How This Survey Was Made." More comprehensive explanations are given in the Soil Survey Manual (*5*) [1]

[1] Italic numbers in parentheses refer to Literature Cited, p. 124.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Mapping unit	Acres	Percent	Mapping unit	Acres	Percent
Antler stony clay loam	696	0.1	Hamar and Ulen loamy sands	480	.1
Antler clay loam	1,417	.2	Hamar and Ulen sandy loams	473	.1
Arveson-Fossum fine sandy loams	708	.1	Hamerly-Cresbard loams	2,286	.3
Arveson-Fossum loams	2,916	.3	Hamerly-Svea loams, nearly level	23,860	2.9
Arvilla sandy loam, nearly level	4,399	.5	Hamerly-Svea loams, gently undulating	15,475	1.9
Arvilla sandy loam, gently sloping	1,538	.2	Hattie silty clay, lacustrine	292	(1)
Barnes loam, rolling	888	.1	Hecla loamy sand, nearly level	6,065	.7
Barnes loam, rolling, eroded	15,757	1.9	Hecla loamy sand, gently undulating	547	.1
Barnes-Buse loams, hilly, eroded	889	.1	Hegne-Fargo silty clays, nearly level	73,530	9.0
Barnes-Buse stony loams	441	.1	Hegne-Fargo silty clays, gently sloping	494	.1
Barnes-Renshaw loams, rolling	751	.1	Hegne silty clay, saline	1,790	.2
Barnes-Sioux complex, hilly	822	.1	Hegne silty clay, strongly saline-alkali	533	.1
Barnes-Svea loams, gently undulating	35,792	4.4	Kloten complex	9,965	1.2
Barnes-Svea loams, gently undulating, eroded	48,823	5.9	Lamoure soils, moderately saline	534	.1
Barnes-Svea stony loams, nearly level	1,411	.2	Lankin loam, level	24,123	2.9
Barnes-Svea stony loams, rolling	1,372	.2	Lankin clay loam	968	.1
Bearden silt loam	5,482	.7	Lankin and Svea loams, nearly level	4,865	.6
Bearden silty clay loam, level	68,840	8.4	Lankin and Svea loams, gently sloping	1,085	.1
Bearden silty clay loam, sloping	940	.1	LaPrairie silt loam	2,158	.2
Bearden silty clay loam, fans	5,394	.7	LaPrairie silty clay loam	2,463	.3
Bearden silty clay loam, saline	9,683	1.2	Ludden silty clay	1,026	.1
Bearden silty clay loam, gravelly substratum	3,198	.4	Ludden and Ryan soils	900	.1
Bearden silty clay	4,731	.6	Maddock-Hecla complex, severely eroded	621	.1
Benoit loam	628	.1	Manfred soils	5,747	.7
Borup silt loam	1,572	.2	Ojata soils	3,824	.4
Brantford-Vang loams, gently sloping	2,715	.3	Overly silt loam, level	7,375	.9
Brantford-Vang loams, sloping	596	.1	Overly silty clay loam, level	12,917	1.6
Buse-Barnes loams, rolling	174	(1)	Overly silty clay loam, gently sloping	1,128	.1
Buse-Barnes loams, hilly	2,653	.3	Overly silty clay loam, sloping	1,171	.1
Buse-Barnes loams, steep	2,868	.3	Overly silty clay loam, fans	9,583	1.2
Cashel silty clay, nearly level	3,163	.4	Overly silty clay, level	4,059	.5
Cashel silty clay, gently sloping	716	.1	Overly silty clay, fans	3,878	.5
Cashel soils, steep	1,282	.2	Parnell silty clay loam	10,309	1.2
Cavour complex	138	(1)	Parnell and Tonka soils	2,816	.3
Coe soils	657	.1	Perella silty clay loam	1,112	.1
Colvin silt loam	1,068	.1	Rauville soils	898	.1
Colvin silty clay loam	2,696	.3	Renshaw loam, nearly level	7,581	.9
Colvin silty clay loam, very wet	446	.1	Renshaw loam, gently sloping	2,259	.3
Divide loam, level	2,252	.3	Rockwell fine sandy loam	3,196	.4
Edgeley loam, nearly level	4,885	.6	Sioux-Renshaw complex	3,688	.4
Edgeley loam, gently undulating	1,286	.2	Sioux and Renshaw soils, steep	666	.1
Edgeley loam, undulating	593	.1	Svea-Barnes loams, nearly level	56,530	6.7
Embden sandy loam, level	9,521	1.1	Svea-Cresbard loams, nearly level	23,189	2.8
Embden sandy loam, gently undulating	498	.1	Towner sandy loam, level	4,946	.6
Embden sandy loam, sloping	259	(1)	Ulen sandy loam	4,075	.5
Embden loam, level	1,418	.2	Vallers loam, saline	747	.1
Fairdale silt loam	4,290	.5	Vallers-Hamerly loams	23,020	2.7
Fairdale silt loam, gently sloping	429	.1	Vallers-Hamerly stony loams	559	.1
Fairdale silt loam, occasionally flooded	5,925	.7	Vang-Brantford loams, nearly level	4,898	.6
Fairdale and LaPrairie soils, channeled	10,495	1.3	Wahpeton silty clay	9,056	1.1
Fargo silty clay, nearly level	14,271	1.7	Walsh loam, sloping	107	(1)
Fargo silty clay, depressional	3,952	.5	Walsh loam, sand substratum, nearly level	1,898	.2
Fargo-Hegne silty clays, level	2,618	.3	Walsh loam, sand substratum, gently sloping	441	.1
Fargo-Hegne silty clays, gently sloping	613	.1	Walsh silt loam	5,323	.6
Gardena silt loam, nearly level	6,925	.8	Walsh clay loam, level	3,858	.5
Gardena silt loam, gently sloping	235	(1)	Waukon loam, gently undulating	567	.1
Gilby loam	20,125	2.4	Waukon loam, strongly rolling	104	(1)
Gilby loam, wet	6,511	.8	Zell-Gardena silt loams, sloping	373	(1)
Gilby stony loam	546	.1	Zell-Gardena silt loams, steep	205	(1)
Glyndon silt loam, level	79,152	9.6	Lakes, ponds, and reservoirs	3,042	.4
Glyndon silt loam, gently sloping	1,270	.2	Gravel pits	440	.1
Glyndon silt loam, moderately saline	1,793	.2	Waste dumps and lagoons	233	(1)
Grano silty clay, very wet	325	(1)	Total	823,680	100.0
Grano-Hegne silty clays	4,882	.6			

[1] Less than 0.05 percent.

Each series description contains a statement about available water capacity, and this capacity is also shown numerically in table 6 in the section "Use of Soils for Engineering." In the series descriptions, the available water capacity is described as *very low*, *low*, *moderate*, *high*, or *very high*. A layer of soil that holds less than 0.05 inch of available water per inch of soil has *very low* available water capacity. The medium and coarse sand at depths of

26 to 60 inches in the Arvilla soils is an example. A layer that holds 0.05 to 0.10 inch of available water per inch of soil has *low* available water capacity; one that holds 0.10 to 0.15 inch per inch of soil has *moderate* available water capacity; one that holds 0.15 to 0.20 inch per inch of soil has *high* available water capacity; and one that holds more than 0.20 inch per inch of soil has *very high* available water capacity.

The available water capacity is considered to be high throughout the entire soil profile if most of the layers have high available water capacity. The layers considered are those at depths to which the roots of plants ordinarily grown in the county penetrate. As an example, the roots of wheat, oats, and barley penetrate the Barnes soils to depths of 36 to 48 inches. All layers in the Barnes soils have available water capacity of 0.16 to 0.20 inch per inch of soil. Hence, the Barnes soils have high available water capacity.

The Arvilla soils, on the other hand, have moderate available water capacity in the uppermost part of the root zone, and they have very low available water capacity in the lower part of the root zone. For those soils the average available water capacity is low, or 3.8 inches in the uppermost 4 feet of soil.

Antler Series

The Antler series consists of deep, somewhat poorly drained, calcareous soils that have formed in moderately deep lacustrine sediment underlain by glacial till. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is about 13 inches thick and is black clay loam in the upper part and very dark gray clay loam in the lower part. Just beneath the surface layer is another layer of clay loam, about 20 inches thick, that contains a large amount of lime. The upper part of this layer is gray and is very strongly calcareous. The lower part is pale olive and is strongly calcareous. Below the layer of limy material is clay loam glacial till that is light yellowish brown to a depth of about 46 inches and is light brownish gray below that depth. In most places a thin layer of gravelly or cobbly material separates the lacustrine material from the underlying glacial till. The glacial till extends to a depth of 60 inches or more.

Permeability is moderately slow, and the available water capacity is high. The water table is within 1 to 4 feet of the soil surface during some parts of the year.

Typical profile of Antler clay loam (0 to 3 percent slopes) in a cultivated area (450 feet south and 30 feet west of the northeast corner of the NW¼ of sec. 30, T. 157 N., R. 54 W.):

Ap—0 to 6 inches, black (10YR 2/1) clay loam, black (10YR 2/1) when moist; cloddy, breaking to moderate, fine, granular structure; very hard when dry, firm when moist, sticky and plastic when wet; noncalcareous; abrupt, smooth boundary.

A1—6 to 13 inches, very dark gray (10YR 3/1) clay loam, black (10YR 2/1) when moist; moderate, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous; contains a few worm channels that are filled with material from the C1ca horizon; contains a few fine pebbles; clear, wavy boundary.

C1ca—13 to 22 inches, gray (N 6/0) clay loam, dark gray (10YR 4/1) when moist; weak, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; very strongly calcareous; contains a few pebbles and a few nodules of lime; abrupt boundary.

IIC2ca—22 to 24 inches, gray (5Y 5/1) pebbly clay loam, olive gray (5Y 5/2) when moist; weak, fine, subangular blocky structure; slightly hard when dry, very friable when moist, sticky when wet; very strongly calcareous; pebbles are predominantly of granitic origin; abrupt, wavy boundary.

IIC3ca—24 to 33 inches, pale-olive (5Y 6/3) clay loam, light olive brown (2.5Y 5/4) when moist; moderate, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; contains a few large crystals of gypsum; abrupt boundary.

IIC4—33 to 46 inches, light yellowish-brown (2.5Y 6/4) clay loam glacial till, olive brown (2.5Y 4/4) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; calcareous; contains many pebbles of shale and granite.

IIC5—46 to 60 inches, light brownish-gray (2.5Y 6/2) clay loam glacial till, olive brown (2.5Y 4/4) when moist; common, medium, distinct, brown and gray mottles; massive; very hard when dry, sticky and plastic when wet; calcareous; contains pebbles of shale and granite and a few nodules of iron oxide and gypsum.

Thickness of the A horizon ranges from 6 to 13 inches. Depth to glacial till ranges from 24 to 40 inches.

Antler soils occur in areas similar to those occupied by the Lankin soils. Their profile contains more lime than that of the Lankin soils, and they lack a B horizon that is typical in the Lankin profile.

Antler stony clay loam (0 to 3 percent slopes) (An).—This soil is on interbeach plains containing small, shallow depressions that trap runoff after heavy rains and periods of snowmelt. The profile is similar to the one described as representative of the series, except that from 3 to 15 percent of the surface layer is stones and boulders. Included with this soil in mapping were small areas of Lankin stony clay loam.

The numerous stones and boulders in the surface layer make cultivation impractical. Therefore, this Antler soil is used mainly for pasture or for native hay. (Capability unit VIs–Si; windbreak site 10)

Antler clay loam (0 to 3 percent slopes) (Ao).—This soil occupies interbeach areas on a glacial lake plain that contains small, shallow depressions. The depressions trap runoff from heavy rains and snowmelt. The profile is the one described as representative of the Antler series. In most places this soil is nonsaline to a depth of 30 inches.

Included with this soil in mapping were small areas where the surface layer is thin. Also included were small areas along road ditches and drainage ditches that are slightly to moderately saline throughout.

This Antler soil is used mainly for cultivated crops, but it is suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitations to its use for crops are its high to moderate susceptibility to soil blowing and the slow rate of water infiltration. Because of the slow rate of infiltration, water ponds on the surface after periods of snowmelt or heavy rainfall. (Capability unit IIe–4L; windbreak site 1)

Arveson Series

The Arveson series consists of deep soils that are poorly drained. These soils are in shallow depressions, on sandy

outwash plains, in interbeach areas, and on deltas. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is about 22 inches thick and is very dark gray, slightly calcareous fine sandy loam in the upper part and mottled dark-gray, strongly calcareous light loam in the lower part. Just beneath the surface layer is a layer of mottled material that contains a large amount of lime and is about 26 inches thick. This layer is grayish-brown, strongly calcareous fine sandy loam in the upper part; light-gray, very strongly calcareous fine sandy loam in the middle part; and white, very strongly calcareous very fine sandy loam in the lower part. Pale-yellow silt that was deposited by water underlies the limy material and extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer, and it is moderately rapid below the surface layer. The available water capacity is moderate. The water table is at the surface or is within 3 feet of the surface during wet periods. It is seldom below a depth of 60 inches, except during extended dry periods.

Typical profile of an Arveson fine sandy loam in a cultivated area (0.3 mile east and 190 feet north of the southwest corner of sec. 3, T. 156 N., R. 55 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) when moist; cloddy, breaking to weak, fine, subangular blocky structure; slightly hard when dry, very friable when moist; slightly calcareous; abrupt, smooth boundary.

A11—6 to 10 inches, very dark gray (10YR 3/1) fine sandy loam, black (N 2/0) when moist; weak, medium, platy structure breaking to weak, fine, crumb structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous; clear, wavy boundary.

A12ca—10 to 22 inches, dark-gray (10YR 4/1) light loam, black (10YR 2/1) when moist; a few, fine, faint, brown mottles when dry; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; a few nodules of manganese; clear, wavy boundary.

C1ca—22 to 26 inches, grayish-brown (2.5Y 5/2) fine sandy loam, very dark grayish brown (2.5Y 3/2) when moist; many, fine, distinct, white mottles and a few, fine, distinct, brown mottles when moist; weak, coarse, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; a few nodules of manganese; abrupt, wavy boundary.

C2gca—26 to 38 inches, light-gray (5Y 7/2) fine sandy loam, olive (5Y 5/3) when moist; a few, fine, prominent, yellowish-brown mottles; weak, coarse, prismatic structure; slightly hard when dry, friable when moist; very strongly calcareous; common nodules of manganese; clear boundary.

C3gca—38 to 48 inches, white (5Y 8/2) very fine sandy loam, pale olive (5Y 6/3) when moist; a few, fine, faint, olive-gray mottles; massive; hard when dry, friable when moist, slightly plastic when wet; very strongly calcareous; a few pebbles.

C4—48 to 60 inches, pale-yellow (5Y 7/3) silt, pale olive (5Y 6/3) when moist; many, medium, prominent, yellowish-brown mottles; massive; hard when dry, very friable when moist; strongly calcareous.

The A horizon ranges from 13 to 22 inches in thickness and from loam to fine sandy loam or sandy loam in texture. Some profiles contain a IICg horizon of fine sand.

The Arveson soils are more poorly drained than the Ulen, Glyndon, and Gilby soils. They contain more lime than the Hamar soils and are coarser textured than the Borup soils. The Arveson soils have a thicker Cca horizon than the Fossum soils.

Arveson-Fossum fine sandy loams (0 to 1 percent slopes) (As).—This mapping unit consists of Arveson and Fossum soils in shallow depressions, where they have formed in sandy water-deposited sediment. These soils occur in such complex patterns that it was impractical to map them separately. About 55 percent of the mapping unit is Arveson fine sandy loam, 40 percent is Fossum fine sandy loam, and 5 percent is other soils. The Arveson soil has the profile described as typical for its series. The profile of the Fossum soil is similar to the one described for the Fossum series, except that the surface layer is fine sandy loam. Included with these soils in mapping were small areas of Ulen soils.

Soils of this mapping unit are used mainly for cultivated crops, but they are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Their poor natural drainage and their high susceptibility to soil blowing are the chief limitations to their use for crops. (Capability unit IIIwe–3; windbreak site 2)

Arveson-Fossum loams (0 to 1 percent slopes) (At).—Soils of this mapping unit are in shallow depressions on sandy outwash plains, in interbeach areas, and on deltas. About 55 percent of the acreage in Arveson loam, 40 percent is Fossum loam, and 5 percent is other soils. The Arveson soil has a profile similar to that described as representative of its series, except that the surface layer is loam. The Fossum soil has the profile described for the Fossum series. Included with these soils in mapping were small areas of Ulen soils.

Soils of this mapping unit are used mainly for cultivated crops, but they are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Their poor natural drainage and their high susceptibility to soil blowing are the chief limitations to their use for crops. (Capability unit IIw–4L2; windbreak site 2)

Arvilla Series

The Arvilla series consists of deep, loamy, excessively drained soils that are underlain by water-deposited coarse sand. These soils have formed under short, medium, and tall prairie grasses.

In a typical profile, the surface layer is very dark gray sandy loam about 10 inches thick. The subsoil is about 16 inches thick. It consists of very dark grayish-brown sandy loam in the upper part and of grayish-brown, strongly calcareous sand in the lower part. Just beneath the subsoil is a layer of sand and coarse sand that contains a large amount of lime and is about 22 inches thick. This layer is yellowish brown and strongly calcareous in the upper part, and it is very pale brown and very strongly calcareous in the lower part. Below this limy material is a layer of yellowish-brown sand and coarse sand that is about 7 inches thick. This is underlain by brown gravelly coarse sand that extends to a depth of 60 inches or more.

The surface layer and the upper part of the subsoil are moderately permeable and have moderate available water capacity; the lower part of the subsoil has moderately rapid permeability and very low available water capacity; and the rest of the profile has rapid permeability and very low available water capacity. The average available water capacity is low. The water table is very deep.

Typical profile of Arvilla sandy loam, nearly level (80 feet north and 40 feet west of the southeast corner of the SW¼ of sec. 1, T. 156 N., R. 56 W.):

A1—0 to 10 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) when moist; weak, fine, crumb structure; soft when dry, very friable when moist; abrupt, wavy boundary.

B2—10 to 19 inches, very dark grayish-brown (10YR 3/2) sandy loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; slightly hard when dry, friable when moist; clear, smooth boundary.

B3ca—19 to 26 inches, grayish-brown (10YR 5/2) sand, dark yellowish brown (10YR 4/4) when moist; single grain; soft when dry, loose when moist; strongly calcareous; contains a few pebbles; clear boundary.

IIC1ca—26 to 38 inches, yellowish-brown (10YR 5/4) sand and coarse sand, brown (10YR 4/3) when moist; single grain; loose when dry or moist; strongly calcareous; clear boundary.

IIC2ca—38 to 48 inches, very pale brown (10YR 7/3) sand and coarse sand, yellowish brown (10YR 5/4) when moist; single grain; loose when dry or moist; very strongly calcareous; diffuse boundary.

IIC3—48 to 55 inches, yellowish-brown (10YR 5/4) sand and coarse sand, dark yellowish brown (10YR 4/4) when moist; single grain; loose when dry or moist; calcareous.

IIC4—55 to 60 inches, brown (10YR 4/3) gravelly coarse sand, dark yellowish brown (10YR 3/4) when moist; single grain; loose when dry or moist; calcareous.

The A horizon ranges from dark grayish brown to very dark gray in color, from loam to sandy loam in texture, and from 5 to 10 inches in thickness. In places the B2 horizon is loam, and it ranges from brown to very dark grayish brown in color and from 9 to 16 inches in thickness. The water-deposited material beneath the B2 horizon contains some gravel, and it contains a small amount of sand-sized particles of shale in some places. Depth to coarse sand and gravel ranges from 14 to 36 inches.

Unlike the Renshaw soils, which have a IIC horizon dominantly of gravel, the Arvilla soils have a IIC horizon of medium and coarse sand. They are deeper over sand than the Sioux soils.

Arvilla sandy loam, nearly level (0 to 3 percent slopes) (AuA).—This soil is on beach lines and deltas. It has the profile described as representative of the series.

Included with this soil in mapping were areas in which the surface layer is sandy loam and the underlying material is gravel; other areas in which the surface layer is loam and the underlying material is coarse sand and gravel; and still other areas in which part of the original surface layer has been lost through soil blowing.

The chief limitations to use of this Arvilla soil for crops are the high susceptibility to soil blowing if cultivated crops are grown, and droughtiness as the result of the low available water capacity and the shallow root zone. This soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. (Capability unit IIIes-3; windbreak site 6)

Arvilla sandy loam, gently sloping (3 to 5 percent slopes) (AuB).—This soil is on terraces and on the side slopes of waterways. Except that the surface layer and the subsoil are thinner, the profile is similar to the one described as representative of the Arvilla series.

Included with this soil in mapping were small areas that are moderately eroded, and small areas in which the surface layer is loam.

The chief limitations to use of this Arvilla soil for crops are the high susceptibility to soil blowing, and droughtiness as the result of the low available water capacity and the shallow root zone. This soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. (Capability unit IIIes-3; windbreak site 6)

Barnes Series

The Barnes series consists of deep, well-drained soils that have formed in calcareous, loamy glacial till on uplands. Numerous potholes are scattered throughout the areas. For most of these soils, the native vegetation was short, medium, and tall prairie grasses. For the gently undulating Barnes soils that are mapped in complexes with the Svea soils, however, and for the nearly level Barnes stony loam that is mapped in a complex with Svea soils, the native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is black loam about 8 inches thick. The subsoil is about 11 inches thick. It is dark-brown and very dark gray light clay loam in the upper part, and is olive-brown loam in the lower part. Just below the subsoil is a layer of pale-olive loam that is about 18 inches thick and contains a large amount of lime. The next layer is light yellowish-brown, strongly calcareous very fine sandy loam glacial till. Underlying this layer is pale-yellow loam glacial till that extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer and the subsoil, and it is moderately slow in the glacial till substratum. The available water capacity is high. These soils have a very deep water table.

Typical profile of Barnes loam, rolling (470 feet south and 340 feet east of the northwest corner of the NE¼ of sec. 31, T. 158 N., R. 56 W.):

A1—0 to 8 inches, black (10YR 2/1) loam, black (10YR 2/1) when moist; weak, very coarse and coarse, angular blocky structure breaking to fine and very fine, crumb structure; very friable when moist, slightly sticky and slightly plastic when wet; abrupt, wavy boundary.

B21—8 to 12 inches, dark-brown (10YR 3/3) and very dark gray (10YR 3/1) light clay loam, very dark grayish brown (10YR 3/2) when moist; has very dark gray (10YR 3/1), thin clay films on the peds when moist; moderate, medium and fine, angular blocky structure; friable when moist, sticky and plastic when wet; abrupt, wavy boundary.

B22—12 to 19 inches, olive-brown (2.5Y 4/4) loam, dark grayish brown (10YR 4/4) when moist; moderate, medium, prismatic structure breaking to moderate, medium and fine, angular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; abrupt, irregular boundary.

C1ca—19 to 37 inches, pale-olive (5Y 6/3) loam, dark yellowish brown (10YR 4/4) when moist; moderate, medium, angular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; very strongly calcareous; gradual, wavy boundary.

C2—37 to 46 inches, light yellowish-brown (2.5Y 6/4) very fine sandy loam, light olive brown (2.5Y 5/4) when moist; medium, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, angular blocky structure; very friable when moist, slightly plastic when wet; strongly calcareous; clear boundary.

C3—46 to 60 inches, pale-yellow (2.5Y 7/4) loam, light olive brown (2.5Y 5/4) when moist; slightly sticky and slightly plastic when wet.

The A horizon ranges from loam to clay loam in texture and from black to very dark gray in color. The B horizon ranges from loam to clay loam in texture and from very dark gray or very dark grayish brown to dark brown or olive brown in color.

Patchy clay films and stains of organic matter are common on the sides of the prisms and blocks in the B horizon. The C horizons beneath the layer where lime has accumulated range from loam or clay loam to very fine sandy loam in texture. The number of glacial stones and boulders throughout the profile ranges from few to many. Depth to the Cca horizon ranges from 15 to 30 inches, but it is generally between 19 and 23 inches. In places from 10 to 20 percent of the C horizons beneath the layer where lime has accumulated is sand and fragments of shale the size of pebbles.

The Barnes soils are better drained than the Svea soils, and they contain less shale than the Edgeley soils. They are better drained and have a thicker solum than the Hamerly soils. The Barnes soils have a thicker A horizon than the Buse soils. Unlike the Hamerly and Buse soils, they have a B horizon.

Barnes loam, rolling (6 to 9 percent slopes) (BaC).—This soil is on glacial till uplands. It has the profile described as representative of the series.

Included with this soil in mapping were small areas of very stony and gravelly soils, areas of Tonka soils in shallow depressions, and small areas of Buse and Hamerly soils.

This Barnes soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, but water erosion is difficult to control in areas that are cultivated. Soil blowing is also a slight hazard. (Capability unit IIIe–6; windbreak site 3)

Barnes loam, rolling, eroded (6 to 9 percent slopes) (BaC2).—This soil is on glacial till uplands. It is moderately eroded. The profile is similar to the one described as representative of the series, except that water erosion has removed part of the original surface layer. In places part of the subsoil has been mixed with the material in the surface layer during tillage. The present surface layer is only 3 to 5 inches thick and is dark gray.

Included with this soil in mapping were a few areas of a severely eroded soil that has had part of the limy material mixed with material in the surface layer during tillage. In those areas the surface layer is pale brown to light yellowish brown. Also included were small areas of Buse soils on the crests of hills, and small areas of Tonka and Parnell soils in depressions.

This Barnes soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and nearly all of the acreage is cultivated. Susceptibility to water erosion is the chief limitation to use of this soil for crops, but soil blowing is also a slight hazard. (Capability unit IIIe–6; windbreak site 3)

Barnes-Buse loams, hilly, eroded (9 to 12 percent slopes (BbD2).—About 50 percent of the acreage in this mapping unit is Barnes loam, 35 percent is Buse loam, and 15 percent is other soils. These soils are on glacial till uplands. They are moderately eroded.

The Barnes soil has a profile similar to the one described as representative of the Barnes series, except that erosion has removed part of the original surface layer and the present surface layer is dark gray. In addition, part of the subsoil has been mixed with the surface soil in some places. The Buse soil has a profile similar to the one described as representative of the Buse series, except that erosion has also removed part of its original surface layer. The present surface layer is lighter colored than the original one, and some material from the layer that is high in content of lime has been mixed with the surface soil during tillage.

Included with these soils in mapping were small areas of uneroded Barnes and Buse soils that have a loam surface layer. Also included were small areas of very stony soils, and small areas of Tonka and Parnell soils in depressions.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Water erosion and droughtiness, caused by the rapid runoff, are the chief limitations to use of these soils for crops. Soil blowing is also a slight to moderate hazard. (Capability unit IVe–6; windbreak site 3)

Barnes-Buse stony loams (9 to 15 percent slopes) (Be).—About 50 percent of this mapping unit is Barnes stony loam, 40 percent is Buse stony loam, and 10 percent is other soils. These soils have a profile similar to the ones described as representative of their respective series, except that the surface layer and the subsoil of the Barnes soil are thinner. The soils are on glacial till uplands, where glacial stones and boulders cover from 15 to 25 percent of the surface. The Barnes soil is on the side slopes of hills and ridges, and the Buse soil is on the tops of the hills and on the crests of the ridges.

Included with these soils in mapping were areas of Tonka and Parnell soils in depressions. Also included were some areas of soils that are on glacial ridges and that have from 25 to 90 percent of the soil surface covered with stones.

Use of the soils of this mapping unit for crops is limited by the numerous stones and boulders. The soils are used mainly for native hay and pasture. (Capability unit VIs–Si; windbreak site 10)

Barnes-Renshaw loams, rolling (3 to 8 percent slopes) (BgC).—About 45 percent of the acreage in this mapping unit is Barnes loam, 35 percent is Renshaw loam, and 20 percent is Sioux and other soils. These soils are on ridges of glacial till, where pockets of gravel are on the crests of the ridges and on some of the side slopes. The Barnes soil is on the side slopes, and the Renshaw and Sioux soils are on the crests of the ridges. The profile of the Barnes soil is similar to the one described as representative of the Barnes series, except that it is generally more gravelly and it has pockets of sand and gravel in the lower part of the substratum. The profile of the Renshaw soil is similar to the one described as representative of the Renshaw series, except that in some places it has pockets of glacial till in the lower part of the substratum.

Included with these soils in mapping were small areas of Sioux gravelly loam and of Tonka and Parnell soils. The Sioux soil is on the crests of ridges, and the Tonka and Parnell soils are in depressions.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Susceptibility to water erosion and a tendency to droughtiness are the chief limitations to use of these soils for crops. The very low available water capacity of the gravelly substratum underlying the Renshaw soil is responsible for the droughtiness of that soil. (Capability unit IIIes–5; the Barnes soil is in windbreak site 3, and the Renshaw soil is in windbreak site 6)

Barnes-Sioux complex, hilly (8 to 15 percent slopes) (BhD).—About 50 percent of this mapping unit is Barnes soil, 35 percent is Sioux soil, and 15 percent is other soils. These soils are on ridges of glacial till that have pockets of sand and gravel on their crests and on some of their side

slopes. The Barnes soil is on the side slopes, and the Sioux soil is on the ridge crests. The profile of the Barnes soil is similar to the one described as representative of the Barnes series, except that in many places it contains more gravel and the lower part of the substratum contains pockets of sand and gravel.

Included with these soils in mapping were small areas of Renshaw loam and of Buse loam.

Soils of this mapping unit are mostly under cultivation. Water erosion, soil blowing, and droughtiness so limit their use, however, that the soils should be reseeded to grass and used for hay or pasture. Several pits where sand and gravel are obtained are within areas of these soils, but the sand and gravel are of poor quality. (Capability unit VIs–SwG; the Barnes soil is in windbreak site 3, and the Sioux soil is in windbreak site 10)

Barnes-Svea loams, gently undulating (3 to 5 percent slopes) (BkB).—About 55 percent of this mapping unit is Barnes loam, 30 percent is Svea loam, and 15 percent is other soils of glacial till plains. The Barnes soil is steeper than the Svea, and it occupies the higher part of the landscape. The Svea soil is in lower, nearly level or concave areas.

Included with these soils in mapping were areas of Tonka and Parnell soils in the many shallow depressions; small areas of Buse loam, Hamerly loam, and Cresbard loam; and small areas of very stony soils and of moderately eroded soils.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Susceptibility to water erosion is the chief limitation to use of these soils for crops. In addition, water from runoff ponds in the many depressions, and it interferes with fieldwork. The soils are also slightly susceptible to soil blowing. (Capability unit IIe–6; the Barnes soil is in windbreak site 3, and the Svea soil is in windbreak site 1)

Barnes-Svea loams, gently undulating, eroded (3 to 5 percent slopes) (BkB2).—This mapping unit consists mainly of moderately eroded Barnes and Svea soils on glacial till uplands. About 55 percent of the mapping unit is Barnes loam, 30 percent is Svea loam, and 15 percent is other soils. The Barnes soil is steeper than the Svea, and it occupies the higher part of the landscape. The Svea soil is mainly in concave areas. The profile of the Barnes soil is similar to the one described as representative of the Barnes series, except that the surface layer is thinner and in places part of the subsoil has been mixed with the surface soil by cultivation. The profile of the Svea soil is similar to the one described as representative of the Svea series, but the surface layer is more variable in thickness because the Svea soil has received some additional material that has washed onto it from the slopes above.

Included with these soils in mapping were areas of Tonka and Parnell soils in the many shallow depressions, and small areas of Buse loam, Hamerly loam, and Cresbard loam. Also included were a few small areas of very stony soils.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Water erosion is the chief limitation to use of these soils for crops. Water from runoff ponds in the numerous depressions in many places, and it interferes with fieldwork. The soils are also slightly susceptible to soil blowing. (Capability unit IIe–6; the Barnes soil is in windbreak 3, and the Svea soil is in windbreak 1)

Barnes-Svea stony loams, nearly level (0 to 3 percent slopes (BlA).—Soils of this mapping unit are on glacial till plains. About 45 percent of the acreage is Barnes stony loam, 40 percent is Svea stony loam, and 15 percent is other soils. The Barnes soil is on the convex slopes, and the Svea soil is in concave areas. The profiles of these soils are similar to the ones described for their respective series, except that from 15 to 25 percent of their surface is covered with stones and boulders.

Included with these soils in mapping were areas of Tonka and Parnell soils in depressions. Also included were small areas of nonstony soils.

Because of the many stones and boulders, the soils of this mapping unit are used only for native hay and pasture. (Capability unit VIs–Si; windbreak site 10)

Barnes-Svea stony loams, rolling (3 to 9 percent slopes) (BlC).—Soils of this mapping unit are on glacial till uplands. About 60 percent of the acreage is Barnes stony loam, 30 percent is Svea stony loam, and 10 percent is other soils. The Barnes soil is on convex slopes, and the Svea soil is in concave areas. These soils have profiles similar to the ones described as representative for their respective series, except that from 15 to 25 percent of the soil surface is covered with stones and boulders.

Included with these soils in mapping were areas of Tonka and Parnell soils in depressions, and small areas of Buse loam, Hamerly loam, and nonstony soils.

Because of the many stones and boulders, the soils of this mapping unit are used only for native hay and pasture. (Capability unit VIs–Si; windbreak site 10)

Bearden Series

The Bearden series consists of deep, calcareous soils that are somewhat poorly drained. These soils have formed in water-deposited sediment in glacial lakes and on alluvial fans, stream levees, and flood plains. The native vegetation was mainly tall prairie grasses. On the saline Bearden soil, however, the native vegetation included salt-tolerant grasses, and on the Bearden soil that has a gravelly substratum, it included deciduous trees and shrubs.

In a typical profile, the surface layer is silty clay loam about 14 inches thick. The surface layer is black and is slightly calcareous in the upper part, and is dark gray and strongly calcareous in the lower part. It has an irregular boundary, and tongues extend downward from the surface layer into the layer immediately below. The layer just beneath the surface layer consists of grayish-brown light silty clay loam that contains a large amount of lime and is about 6 inches thick. The next layer is about 28 inches thick. It is light olive-brown, mottled silty clay loam in the upper part and is light olive-brown, mottled silty clay in the lower part. Beneath this layer is light brownish-gray, mottled varved clay that extends to a depth of 60 inches or more.

Permeability is moderately slow, and the available water capacity is very high. The water table is within 3 to 5 feet of the soil surface during wet periods.

Typical profile of Bearden silty clay loam, level, in a cultivated field (300 feet east and 100 feet north of the

corner of the field, near the southwest corner of sec. 13, T. 157 N., R. 52 W.):

Ap—0 to 6 inches, black (10YR 2.5/1) silty clay loam, black (10YR 2/1) when moist; cloddy, breaking to weak, very fine, crumb structure; friable when moist, sticky and plastic when wet; slightly calcareous; abrupt, smooth boundary.

A11—6 to 9 inches, black (10YR 2.5/1) silty clay loam, black (10YR 2/1) when moist; moderate, medium, angular blocky structure breaking to moderate, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; slightly calcareous; clear, irregular boundary.

A12ca—9 to 14 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; weak, medium, subangular blocky structure breaking to weak, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; strongly calcareous; clear boundary.

C1ca—14 to 20 inches, grayish-brown (2.5Y 5/2) light silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, medium, subangular blocky structure breaking to moderate, very fine, angular blocky structure; firm when moist, sticky and plastic when wet; strongly calcareous; clear boundary.

C2—20 to 32 inches, light olive-brown (2.5Y 5/4) silty clay loam, olive brown (2.5Y 4/4) when moist; few, fine, faint, light-gray mottles; moderate, fine, angular blocky structure; firm when moist, very sticky and very plastic when wet; slightly calcareous and contains a few nodules of lime.

C3—32 to 40 inches, light olive-brown (2.5Y 5/4) silty clay loam, olive brown (2.5Y 4/4) when moist; common, fine, faint, light-gray mottles; moderate, fine, angular blocky structure; firm when moist, very sticky and very plastic when wet; strongly calcareous and contains many nodules of lime.

C4—40 to 48 inches, light olive-brown (2.5Y 5/4) silty clay, olive brown (2.5Y 4/4) when moist; common, medium, prominent, yellowish-brown mottles and many, fine, faint, light olive-gray mottles and a few, medium, prominent, strong-brown mottles when moist; massive; very firm when moist, very sticky and very plastic when wet; slightly calcareous.

C5—48 to 60 inches, light brownish-gray (2.5Y 6/2) varved clay, olive brown (2.5Y 4/4) when moist; many, medium, distinct, strong-brown mottles; very firm when moist, very sticky and very plastic when wet; noncalcareous.

Thickness of the A horizon ranges from 6 to 15 inches. Color of that horizon ranges from black or dark gray to dark grayish brown, and texture ranges from silt loam to silty clay loam or silty clay. Color of the C1ca horizon ranges from grayish brown or dark grayish brown to gray or dark gray. Below the C1ca horizon, the C horizon is dominantly slightly calcareous to strongly calcareous. It has a dominant texture of silty clay loam, but in some places it contains thin layers that range from silt to clay in texture. In others the C horizon consists of sand and gravel below depths of 42 to 60 inches. Where these soils are on stream levees or alluvial fans, they commonly contain very dark colored, buried horizons. In places these soils are nonsaline, but in other areas they are slightly to moderately saline throughout.

The Bearden soils have a profile similar to those of the Glyndon and Hegne soils, and they have similar drainage. They have more clay below the A horizon than the Glyndon soils, however, and they have less clay throughout the profile than the Hegne soils. The Bearden soils occur near Colvin soils, but they are better drained than those soils. They have lime higher in their profile than the Overly soils.

Bearden silt loam (0 to 3 percent slopes) (Bm).—This soil has formed in lacustrine sediment on glacial lake plains. Its profile is similar to the one described as typical of the series, except that the surface layer and the layer that is high in content of lime are both silt loam.

Included with this soil in mapping were areas of Colvin silt loam as large as 3 acres. Also included were areas of Glyndon silt loam and of Bearden silty clay loam. The included soils make up from 5 to 10 percent of the acreage in the mapping unit.

This Bearden soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The moderate to high susceptibility to soil blowing and the somewhat poor drainage are limitations to use of this soil for crops. In some places where outlets are available, drainage has been improved by installing surface drains. (Capability unit IIe–4L; windbreak site 1)

Bearden silty clay loam, level (0 to 3 percent slopes) (BnA).—This soil has formed in lacustrine sediment. It is on a glacial lake plain, where the topography consists of an irregular pattern of ridges, only 6 to 12 inches high, that are separated by slightly concave areas. The profile is the one described as representative of the series.

Included with this soil in mapping were small areas of Perella and Colvin soils. Also included were small areas of soils that lack the high lime content of the Bearden soils and that have a clay subsoil high in content of sodium. Other inclusions consist of poorly drained soils that are in depressions and that have a silt loam subsurface layer 2 to 13 inches thick, have a clay subsoil, and lack the high lime content of the Bearden soils.

This Bearden soil is suited to the commonly grown field crops, hay crops, and pasture plants. It is moderately to highly susceptible to soil blowing, however, and has somewhat restricted drainage. In areas where outlets are available, drainage can be improved by installing surface drains. (Capability unit IIe–4L; windbreak site 1)

Bearden silty clay loam, sloping (3 to 9 percent slopes) (BnC).—This soil has formed in lacustrine sediment on side slopes along drainageways and streams that dissect the glacial lake plain. Its profile is similar to the one described as representative of the series, except that the surface layer is generally thinner and is dark grayish brown in most places. Some areas contain a dark-colored buried horizon.

Included with this soil in mapping were areas of Overly silty clay loam in low spots. Also included were areas of LaPrairie silty clay loam on bottoms along narrow stream channels.

This Bearden soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, but it is moderately to highly susceptible to soil blowing and water erosion. Water erosion is difficult to control if natural drainageways that carry a large amount of runoff are cultivated. (Capability unit IIe–4L; windbreak site 1)

Bearden silty clay loam, fans (0 to 3 percent slopes) (Bo).—This soil is on natural levees along streams, where it has formed in water-deposited sediment. Its profile is similar to the one described as representative of the series, except that the substratum commonly contains a very dark colored buried horizon.

Included with this soil in mapping were small, moderately eroded areas of Overly silty clay loam, fans.

This Bearden soil is moderately to highly susceptible to soil blowing, but it is suited to the commonly grown field crops, hay crops, and pasture plants. Nearly all of the acreage is cultivated. A few noncultivated areas are

used for pasture. (Capability unit IIe-4L; windbreak site 1)

Bearden silty clay loam, saline (0 to 3 percent slopes) (Br).—This moderately saline soil is on glacial lake plains, where it has formed in lacustrine sediment. The profile is similar to the one described as representative of the series, except that the surface layer is generally very dark gray and contains salt crystals. The salt crystals are visible in most places. They increase in number with increasing depth.

Included with this soil in mapping were areas of a nonsaline Bearden silty clay loam, a nonsaline Bearden silt loam, and a nonsaline Colvin silty clay loam. Together these included soils make up from 10 to 20 percent of the acreage in the mapping unit.

The high content of salts, somewhat poor drainage, and moderate to high susceptibility to soil blowing limit use of this saline Bearden soil for crops. Large areas of this soil are cultivated, but the crops are adversely affected by the salts. (Capability unit IIIws-4; windbreak site 9)

Bearden silty clay loam, gravelly substratum (0 to 3 percent slopes) (Bs).—This soil is on the flood plains of streams and in intermittent drainageways. Its profile is similar to the one described as representative of the series, except that the lower part of the substratum contains layers of coarse sand and gravel. Figure 7 shows a profile of this soil in which many roots have penetrated to a depth of 32 inches.

Included with this soil in mapping were small areas of LaPrairie silty clay loam and of very poorly drained Rauville soils.

This Bearden soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitation to use of this soil for crops is wetness caused by seasonal flooding and by the somewhat poor natural drainage. Areas that are cultivated are also moderately to highly susceptible to soil blowing. In some places drainage has been improved by constructing field drains. (Capability unit IIw-4L; windbreak site 1)

Bearden silty clay (0 to 3 percent slopes) (Bt).—This soil is on glacial lake plains. It has a profile similar to the one described as representative of the series, except that the surface layer is silty clay.

Included with this soil in mapping were areas of Fargo silty clay and of Hegne silty clay. Together these included soils make up from 5 to 20 percent of the acreage in the mapping unit.

In general, this Bearden soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. Wetness as a result of the somewhat poor drainage is the chief limitation to use of this soil for crops. In some areas where outlets are available, drainage has been improved by constructing field drains. Cultivated areas of this soil are moderately to highly susceptible to soil blowing. (Capability unit IIwe-4; windbreak site 1)

Benoit Series

The Benoit series consists of very poorly drained and poorly drained, nearly level soils on interbeach plains and deltas. These soils have formed in loamy material that is shallow to moderately deep over sand and gravel. The native vegetation was tall prairie grasses and sedges.

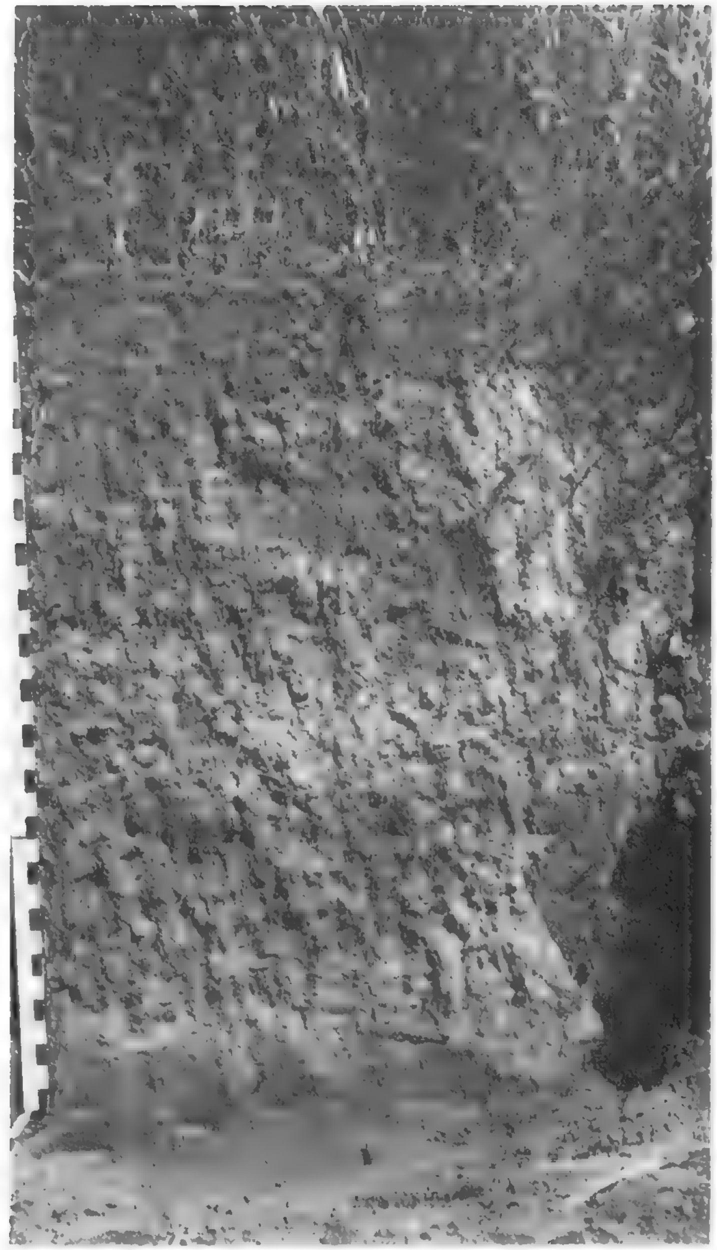

Figure 7.—**Profile of Bearden silty clay loam, gravelly substratum. This soil formed under tall grasses and deciduous trees and shrubs.**

In a typical profile, the surface layer is strongly calcareous and is gray loam in the upper part and is very dark gray clay loam in the lower part. It is about 13 inches thick. Just beneath the surface layer is a layer that is about 18 inches thick and that contains a large amount of lime. This layer of limy material is gray, very strongly calcareous clay loam in the upper part and is pale-yellow, mottled, strongly calcareous sandy loam in the lower part. The next layer is about 19 inches thick and consists of grayish-brown, slightly calcareous gravelly

coarse sand. It is underlain by light olive-gray fine shale sand that extends to a depth of 60 inches or more.

In the surface layer and in the layer where lime has accumulated, permeability is moderately slow and the available water capacity is high. Below these layers, permeability is rapid and the available water capacity is very low. The average available water capacity is low. The water table is at the surface or is within 3 feet of the surface during wet periods.

Typical profile of Benoit loam in a cultivated field (0.6 mile south and 470 feet west of the northeast corner of sec. 4, T. 158 N., R. 56 W.):

Apca—0 to 6 inches, gray (N 5/0) loam, black (N 2/0) when moist; moderate, very fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; abrupt, smooth boundary.

A1ca—6 to 13 inches, very dark gray (N 3/0) clay loam, very dark gray (5Y 3/1) when moist; moderate, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; strongly calcareous; clear, irregular boundary; tongues from this layer extend downward to a depth of 17 inches.

C1ca—13 to 19 inches, gray (N 6/0) clay loam, very dark gray (5Y 3/1) when moist; moderate, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; very strongly calcareous.

IIC2ca—19 to 31 inches, pale-yellow (5Y 7/3) sandy loam, olive gray (5Y 4/2) when moist; many, coarse, prominent, dark yellowish-brown mottles; single grain; friable when moist; strongly calcareous.

IIC3—31 to 50 inches, grayish-grown (2.5Y 5/2) gravelly coarse sand, very dark grayish brown (2.5Y 3/2) when moist; single grain; loose when dry or moist; slightly calcareous; gravel consists of rounded and broken pebbles of shale.

IIC4—50 to 60 inches, light olive-gray (5Y 6/2) fine shale sand, dark olive gray (5Y 3/2) when moist; single grain; loose when dry or moist; slightly calcareous.

Texture of the Apca horizon ranges from loam to fine sandy loam. In some places where glacial till is below a depth of 5 feet, these soils are stony.

The Benoit soils have more coarse sand and gravel in their substratum than the Fossum soils, and they are more poorly drained than the Divide soils.

Benoit loam (0 to 2 percent slopes) (Bu).—This soil is on interbeach plains and deltas. It is the only soil of the Benoit series mapped in Walsh County. Included with this soil in mapping were small areas of a soil that is slightly to moderately saline.

In most places this Benoit soil has a cover of native vegetation. The chief limitations to its use for crops are the restricted natural drainage and the moderate to high susceptibility to soil blowing where cultivated crops are grown. (Capability unit Vw-WL; windbreak site 10)

Borup Series

The Borup series consists of deep, poorly drained soils that contain a large amount of lime. These soils are in shallow depressions on the glacial lake plain and in interbeach areas. They have formed in medium-textured lacustrine deposits. The native vegetation was tall prairie grasses.

In a typical profile, the surface layer is very dark gray, calcareous silt loam about 8 inches thick. Just beneath the surface layer is a layer, about 20 inches thick, that contains a large amount of lime. This layer is light brownish-gray, mottled, very strongly calcareous silt loam in the upper part and is light yellowish-brown, mottled, strongly calcareous very fine sandy loam in the lower part. The next layer is about 13 inches thick and consists of light yellowish-brown, mottled, calcareous very fine sandy loam. Underlying this layer is light yellowish-brown, mottled, calcareous silty clay loam that extends to a depth of 60 inches or more.

Permeability is moderate, and the available water capacity is high. The water table is at the surface or is within 5 feet of the surface. It is highest in spring, when the weather is most likely to be wet.

Typical profile of Borup silt loam in a cultivated field (150 feet east and 300 feet south of the northwest corner of the SW¼ of sec. 34, T. 158 N., R. 52 W.):

A1—0 to 8 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; cloddy, but breaks easily to moderate, fine, granular structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; calcareous; abrupt, wavy boundary.

C1ca—8 to 18 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; a few, fine, faint, brown mottles; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, plastic and slightly sticky when wet; very strongly calcareous; clear, wavy boundary.

C2ca—18 to 28 inches, light yellowish-brown (2.5Y 6/4) very fine sandy loam, light olive brown (2.5Y 5/4) when moist; common, fine, distinct, brown mottles; very weak, coarse, prismatic structure breaking easily to weak, very fine, subangular blocky structure; slightly hard when dry, very friable when moist; strongly calcareous; contains a few nodules of manganese; clear, wavy boundary.

C3—28 to 41 inches, light yellowish-brown (2.5Y 6/4) very fine sandy loam, light olive brown (2.5Y 5/4) when moist; many, medium, distinct, brown and gray mottles; massive; soft when dry, very friable when moist; calcareous; contains a few nodules of manganese; abrupt boundary.

IIC4—41 to 60 inches, light yellowish-brown (2.5Y 6/4) silty clay loam, light olive brown (2.5Y 5/4) when moist; many, fine, prominent, brown and gray mottles; massive; very hard when dry, firm when moist, sticky and very plastic when wet; calcareous; contains many nodules of iron and manganese and a few nodules of lime.

The A horizon ranges from 7 to 15 inches in thickness. Color of the Cca horizon ranges from light yellowish brown or light brownish gray to light olive gray, olive, or olive brown, with mottles of yellowish brown and brown. In some areas the C3 horizon consists of stratified very fine sandy loam, loam, and silty clay loam.

The Borup soils are more poorly drained than the Glyndon soils, and they contain less clay than the Colvin soils. The Borup soils have more clay below the A horizon than the Arveson soils.

Borup silt loam (0 to 3 percent slopes) (Bv).—This is the only soil of the Borup series mapped in this county. It is in depressions and is on the glacial lake plain. Water ponds on the surface in the spring.

Included with this soil in mapping were areas of Glyndon silt loam and of Perella silt loam that together make up from 5 to 15 percent of the acreage of this mapping unit. Also included in some places were small areas that are moderately saline.

Poor drainage is the chief limitation to use of this Borup soil for crops. Most of the areas have been drained, however, and in those places this soil is suited to the commonly grown field crops, hay crops, and pasture plants. Areas that have not been drained are well suited to native hay and

pasture. Where outlets are available, drainage has been improved by constructing field drains. (Capability unit IIw–6; windbreak site 2)

Brantford Series

The Brantford series consists of well-drained soils that have formed in shallow, loamy material over shaly gravel and sand. These soils occur in areas underlain by gravelly outwash. The native vegetation was mainly short, medium, and tall prairie grasses.

In a typical profile, the surface layer is very dark gray loam about 6 inches thick. The subsoil is about 14 inches thick and is grayish-brown loam in the upper part and is light brownish-gray loam in the lower part. The upper part of the substratum is light olive-gray gravelly sand about 9 inches thick. The lower part of the substratum is gray shale gravel and sand that extend to a depth of 60 inches or more.

In the surface layer and the subsoil, permeability is moderate and the available water capacity is high. In the substratum, permeability is very rapid and the available water capacity is very low. The average available water capacity is low. The water table is very deep.

Typical profile of a Brantford loam in a cultivated field (240 feet west and 0.2 mile south of the northeast corner of sec. 23, T. 155 N., R. 57 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; weak, coarse and medium, subangular blocky structure breaking easily to weak. fine, crumb structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; contains a few small shale chips; abrupt, smooth boundary.

B2—6 to 13 inches, grayish-brown (2.5Y 5/2) loam, very dark grayish brown (10 YR 3/2) when moist; moderate, coarse, prismatic structure breaking easily to moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common small shale chips; gradual, wavy boundary.

B3—13 to 20 inches, light brownish-gray (2.5Y 6/2) loam, olive brown (2.5Y 4/4) when moist; weak, coarse, prismatic structure breaking easily to weak and moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly plastic when wet; common small shale chips and a few shale pebbles; abrupt, wavy boundary.

IIC1—20 to 29 inches, light olive-gray (5Y 6/2) gravelly sand, dark grayish-brown (2.5Y 4/2) when moist; single grain; loose when dry or moist; more than 50 percent of horizon is shale gravel and shale sand.

IIC2—29 to 60 inches, gray (5Y 5/1) shale gravel and shale sand, olive gray (5Y 4/2) when moist; single grain; loose when dry or moist; more than 60 percent of horizon is shale gravel and shale sand.

The A horizon ranges from 4 to 9 inches in thickness and is dark gray in places. It contains few to common particles of sand, pebble-sized fragments of shale, and few to common granitic pebbles and stones. Depth to shaly sand and gravel ranges from 14 to 20 inches. In most places these soils are noncalcareous to a depth of at least 60 inches, but the upper part of the IIC horizon contains a slight to moderate amount of lime in a few places. The low chroma and the yellowish or olive hues in the upper part of the IIC horizon are inherited from the material in which these soils formed.

Unlike the Sioux and Renshaw soils, the Brantford soils are underlain by shaly sand and gravel. They are shallower over sand and gravel than the Vang and Walsh soils, and they are deeper over sand and gravel than the Coe soils.

Brantford-Vang loams, gently sloping (3 to 5 percent slopes) (BwB).—This mapping unit consists mainly of Brantford and Vang soils that occur in such complex patterns that it was impractical to map them separately. About 60 percent of the acreage is Brantford loam, and about 40 percent is Vang loam. The Brantford soil has the profile described as representative for the Brantford series. These soils are on outwash plains and along shallow drainageways. The Brantford soil is steeper than the Vang, and it is on the convex slopes. The Vang soil is in concave areas at the base of slopes.

Included with these soils in mapping were a few moderately eroded areas that have a thinner surface layer than normal for Brantford and Vang soils.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitations to use of these soils for crops are droughtiness as a result of the shallow to moderately deep root zone, the low available water capacity of the substratum, and the moderate susceptibility to soil blowing and water erosion. (Capability unit IIIes–5; the Brantford soil is in windbreak site 6, and the Vang soil is in windbreak site 3)

Brantford-Vang loams, sloping (6 to 9 percent slopes) (BwC).—Soils of this mapping unit are in areas underlain by glacial outwash. About 70 percent of the acreage is Brantford loam, and about 30 percent is Vang loam. The Brantford soil is steeper than the Vang and is on the upper convex slopes. The Vang soil occurs in concave areas at the base of the slopes.

Included with these soils in mapping were some moderately eroded areas that have a thinner surface layer than normal for Brantford and Vang soils.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitations to use of these soils for crops are droughtiness as a result of the shallow to moderately deep root zone, the low available water capacity of the substratum, and the moderate susceptibility to soil blowing and water erosion. (Capability unit IIIes–5; the Brantford soil is in windbreak site 6, and the Vang soil is in windbreak site 3)

Buse Series

The Buse series consists of deep, excessively drained soils that have formed in glacial till. These soils are on uplands and on the side slopes of large coulees. The native vegetation was mainly short, medium, and tall prairie grasses.

In a typical profile, the surface layer is dark-gray loam about 7 inches thick. Just below the surface layer is a layer of light-gray loam that contains a large amount of lime and is about 16 inches thick. Underlying this limy material is a layer of pale-yellow, calcareous light clay loam glacial till that extends to a depth of 60 inches or more.

Permeability is moderately slow, and the available water capacity is high. The water table is very deep.

Typical profile of a Buse loam (200 feet north and 100 feet west of the southeast corner of sec. 22, T. 157 N., R. 56 W.):

A1—0 to 7 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) when moist; cloddy, but crushes to moderate fine granules; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; calcareous; abrupt, wavy boundary.

C1ca—7 to 14 inches, light-gray (2.5Y 7/2) loam, light olive brown (2.5Y 5/4) when moist; moderate, medium, prismatic structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; very strongly calcareous; clear, wavy boundary.

C2ca—14 to 23 inches, light-gray (2.5Y 7/2) loam, light olive brown (2.5Y 5/4) when moist; strong, fine, angular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; very strongly calcareous; abrupt, wavy boundary.

C3—23 to 60 inches, pale-yellow (2.5Y 7/4) light clay loam, olive brown (2.5Y 4/4) when moist; moderate, medium, angular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; calcareous.

Where these soils have a thick cover of native vegetation, the A horizon ranges from 3 to 7 inches in thickness. In many places where cultivated crops have been grown, however, part of the A horizon has been lost through erosion, and tillage has mixed soil material from the upper part of the Cca horizon with that remaining in the A horizon. The C horizons are loam or clay loam, and their color ranges from light gray or pale yellow to light olive brown or light yellowish brown. In most places the profile contains a few stones. In some areas east of Lankin, abundant glacial stones and boulders are on the surface and in the soil profile.

Unlike the Barnes soils, the Buse soils lack a B horizon. They differ from the Coe and Sioux soils in being underlain by glacial till, and they are deeper over shale bedrock than the Kloten soils. In contrast to the Zell soils, which have formed in lacustrine sediment that is free of stones, the Buse soils have formed in glacial till that contains stones.

Buse-Barnes loams, rolling (6 to 9 percent slopes) (ByC).—About 50 percent of this mapping unit consists of Buse loam, 40 percent is Barnes loam, and 10 percent consists of other soils. These soils are on glacial till uplands. The Buse soil is on the upper convex slopes and knolls, and the Barnes soil is on the lower convex slopes.

Included with these soils in mapping were small areas of Parnell, Tonka, and Svea soils. The Parnell and Tonka soils are in depressions, and the Svea soils are in concave swales.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. The chief limitation to use of these soils for crops is their moderate to high susceptibility to soil blowing and water erosion. (Capability unit IVe-4L; the Buse soil is in windbreak site 8, and the Barnes soil is in windbreak site 3)

Buse-Barnes loams, hilly (9 to 12 percent slopes) (ByD).—About 50 percent of this mapping unit is Buse loam, 35 percent is Barnes loam, and 15 percent is other soils. These soils are on glacial till uplands. The Buse soil is on the higher convex slopes, and the Barnes soil is on the lower convex slopes.

Included with these soils in mapping were small areas of Parnell, Tonka, and Svea soils. The Parnell and Tonka soils are in depressions, and the Svea soils are in concave swales.

Soils of this mapping unit are mainly in pasture and hay. Because of the rapid runoff, they tend to be droughty if they are cultivated. The soils are also highly susceptible to soil blowing and water erosion. (Capability unit VIe-Si; windbreak site 8)

Buse-Barnes loams, steep (12 to 25 percent slopes) (ByE).—About 60 percent of this mapping unit is Buse loam, 30 percent is Barnes loam, and 10 percent is other soils. The Buse soil has the profile described as representative of the Buse series. These soils are on glacial moraines and on the side slopes of deep coulees. The Buse soil is on the high convex slopes and on ridgetops, and the Barnes soil is on the lower convex slopes.

Included with these soils in mapping were small areas that are stony, small areas where shale crops out at the surface, and small areas of soils that are shallow over bedded shale. Also included were small areas of Parnell and Tonka soils in depressions and of Svea soils in concave swales. Other inclusions that occupy a few areas on ridges and hilltops contain small deposits of gravel.

Soils of this mapping unit are mostly in pasture and hay. Where they are cultivated, the rapid runoff tends to make them droughty and they are highly susceptible to soil blowing and water erosion. Where these soils are cultivated, they are moderately to severely eroded in most places. (Capability unit VIe-Si; windbreak site 10)

Cashel Series

The Cashel series consists of somewhat poorly drained, young soils that have formed in calcareous, fine-textured river deposits. These soils are on the banks and the first flood plains of the Red River and its tributaries. The native vegetation was mainly tall prairie grasses and deciduous trees and shrubs.

In a typical profile, the surface layer is gray, slightly calcareous silty clay about 8 inches thick. Just beneath the surface layer are gray flood plain deposits, typically consisting of a layer of gray silty clay about 3 inches thick. The next layer is the surface layer of a buried soil, consisting of dark grayish-brown silty clay about 3 inches thick. Underlying this layer is grayish-brown silty clay that extends to a depth of 60 inches or more. Some of the lower layers contain snail shells and small pieces of weathered wood.

Permeability is moderately slow throughout the profile, and the available water capacity is high. Flooding is a hazard in spring in about 6 out of 10 years. The floodwaters generally remain for only short periods, but the duration of flooding depends on the amount of snow that has fallen, on the rate of snowmelt, and on the amount of rainfall received in spring. Each time the areas are flooded, the floodwaters deposit fresh sediment. Some areas along the main channel are subject to streambank erosion. Except when flooding occurs, the water table is very deep.

Typical profile of Cashel silty clay, nearly level, east of a farmstead (in the SW¼ of sec. 13, T. 155 N., R. 51 W.):

A1—0 to 8 inches, gray (10YR 5/1) silty clay, very dark brown (10YR 2/2) when moist; strong, very fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; slightly calcareous; abrupt, smooth boundary.

C1—8 to 11 inches, gray (2.5Y 5/1) silty clay, very dark grayish brown (2.5Y 3/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; slightly calcareous; abrupt, smooth boundary.

A1b—11 to 14 inches, dark grayish-brown (2.5Y 4/2) silty clay, black (10YR 2/1) when moist; moderate, medium and fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; slightly calcareous; abrupt, smooth boundary.

C2—14 to 60 inches, grayish-brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; strong, fine, angular blocky structure; hard when dry, friable when moist, very sticky and very plastic when wet; contains two dark horizontal bands; slightly calcareous, and contains a few threads of segregated lime and a few snail shells.

The A horizon ranges from 6 to 16 inches in thickness, and it is clay in some places. In some areas the C1 horizon is grayish brown. As a rule, the horizons below the A horizon are calcareous, but thin layers of noncalcareous material are present in some places. In some areas the profile contains more than one surface layer of a buried soil. Color of the substratum ranges from black or very dark gray to very dark grayish brown or olive gray. The layers in the substratum range from less than 1 inch to several inches in thickness.

The Cashel soils have a thinner, light-colored A horizon and have stronger stratification than the Wahpeton soils. They lack the accumulation of lime that is characteristic in the profile of the Hegne soils. The Cashel soils have more clay throughout their profile than the Fairdale soils.

Cashel silty clay, nearly level (0 to 3 percent slopes) (CaA).—This soil has formed in alluvium on flood plains along the Red River. It is subject to frequent flooding in spring, but flooding is of short duration. Surface drainage and internal drainage are good enough that this soil is ready for cultivation soon after the floodwaters recede. The profile is the one described as representative of the series.

Included with this soil in mapping were small areas of Wahpeton silty clay. These included areas make up from 5 to 15 percent of the acreage of this mapping unit.

This Cashel soil is suited to the commonly grown field crops, hay crops, and pasture plants, and about 50 percent of the acreage is cultivated. Areas not cultivated have a cover of native vegetation and are used for grazing and for wildlife habitat. This soil is moderately to highly susceptible to soil blowing if it is cultivated. (Capability unit IIe-4; windbreak site 1)

Cashel silty clay, gently sloping (3 to 5 percent slopes) (CaB).—This soil occupies short slopes on flood plains, where the topography has been affected by the scouring action of floodwaters. Oxbows and partly filled, abandoned stream channels form depressions in which water is ponded for several weeks after the floodwaters recede.

Included with this soil in mapping were areas of Cashel silty clay, nearly level. This included soil makes up from 5 to 15 percent of the acreage of this mapping unit.

About half of the acreage has been cleared and is used for cultivated crops. Areas not cultivated are in native vegetation and are used for pasture and as wildlife habitat. This soil is suited to the commonly grown field crops, hay crops, and pasture plants, but it is moderately to highly susceptible to soil blowing if it is cultivated. Flooding is frequent, but the floodwaters recede rapidly, except in the depressions. (Capability unit IIe-4; windbreak site 1)

Cashel soils, steep (0 to 25 percent slopes) (CcE).—These soils are adjacent to the Red River. The areas extend from the top of the bank to the edge of the river and are 200 to 500 feet wide. The profile is similar to the one described as representative of the series, except that the surface layer is clay in some places.

These soils are too steep and too susceptible to erosion to be suitable for cultivated crops. Nearly all of the acreage is in timber and is used as wildlife habitat. Streambank erosion is a major hazard because of the quantity and velocity of the floodwaters. The streambanks are protected, to some extent, however, by the stands of native trees that grow on this soil. (Capability unit VIIIe-1; windbreak site 10)

Cavour Series

The Cavour series consists of deep, somewhat poorly drained soils that have formed in calcareous glacial till. The native vegetation was short and medium prairie grasses.

In a typical profile, the surface layer is dark-gray clay loam about 6 inches thick. The subsoil is dark-gray clay about 3 inches thick. The substratum consists of thin layers of clay, sandy clay, and silty clay. The uppermost part of the substratum is grayish-brown and dark grayish-brown clay; the middle part is grayish-brown, mottled sandy clay that is underlain by a layer of light olive-gray, mottled silty clay containing a large amount of lime; and the lower part is light olive-gray, mottled clay. Nests of gypsum crystals and other salts are scattered throughout the substratum. Bedded shale is at a depth of about 40 inches.

These soils are slowly permeable and have moderate available water capacity. The underlying shale is also slowly permeable, and it has low available water capacity. A seasonal high water table is within 3 to 5 feet of the soil surface.

Typical profile of a Cavour clay loam (0.25 mile east of the northwest corner of the SW¼ of sec. 12, T. 157 N., R. 57 W.):

A1—0 to 4 inches, dark-gray (10YR 4/1) clay loam, black (10YR 2/1) when moist; cloddy; hard when dry, firm when moist, sticky and very plastic when wet; clear boundary.

AB—4 to 6 inches, dark-gray (10YR 4/1) clay loam, black (10YR 2/1) when moist; moderate, coarse, angular blocky structure; hard when dry, firm when moist, sticky and very plastic when wet; abrupt boundary.

B2t—6 to 9 inches, dark-gray (10YR 4/1) clay, very dark brown (10YR 2/2) when moist; strong, medium, prismatic structure breaking to strong, medium and fine, subangular blocky structure; hard when dry, very firm when moist, very sticky and very plastic when wet; continuous, distinct clay films on all ped surfaces; few threads of salt; clear boundary.

C1—9 to 14 inches, grayish-brown (2.5Y 5/2) and dark grayish-brown (2.5Y 4/2) clay, very dark grayish brown (2.5Y 3/2) when moist; massive; hard when dry, firm when moist, very sticky and very plastic when wet; clear boundary.

C2cs—14 to 19 inches, grayish-brown (2.5Y 5/2) sandy clay, very dark grayish brown (2.5Y 3/2) when moist; common, fine, prominent, white mottles; massive; hard when dry, very sticky and very plastic when wet; threads and nests of gypsum; clear boundary.

C3cacs—19 to 30 inches, light olive-gray (5Y 6/2) silty clay, olive (5Y 4/3) when moist; few, fine, faint, brown mottles; massive; hard when dry, friable when moist; few particles of shale; strongly calcareous, and lime occurs in fine masses.

C4—30 to 40 inches, light olive-gray (5Y 6/2) clay, olive (5Y 4/3) when moist; common, fine, prominent, white mottles; very hard when dry, very firm when moist; shaly glacial till; slightly calcareous.

IIC5—40 inches +, bedded shale.

The A horizon ranges from 2 to 8 inches in thickness, and it has a texture of loam or clay loam. In some places the profile contains a very dark gray A2 horizon that has platy structure and is 1 to 6 inches thick. In places the B horizon

has strong columnar structure and has continuous clay films and dark coatings of organic matter on the peds. Depth to shale is greater than 60 inches in a few places.

The Cavour soils have a thinner A horizon than the Cresbard soils. Unlike the Barnes, Svea, Edgeley, Hamerly, and Vallers soils, they have a subsoil that is a strongly developed claypan.

Cavour complex (0 to 3 percent slopes) (Cd).—Soils of this complex are on glacial till plains. About 60 percent of the acreage consists of Cavour soils that have a dense claypan subsoil. About 40 percent consists of small areas of Cresbard, Barnes, Svea, and Hamerly soils that were included with these Cavour soils in mapping.

The chief limitations to use of this Cavour complex for crops are droughtiness as a result of the shallow root zone, and salinity of the subsoil and the substratum. The soils are suited to the commonly grown field crops, hay crops, and pasture plants, however, although all the crops are adversely affected by lack of moisture and by the high content of salts. (Capability unit VIs–Cp; windbreak site 9)

Coe Series

The Coe series consists of excessively drained soils on ridges and terraces comprised of water-deposited shale gravel and shale sand. These soils have formed in loamy material that is shallow over the gravel and sand. The native vegetation was short and medium prairie grasses.

In a typical profile, the surface layer is very dark grayish-brown gravelly loam about 5 inches thick. The soil material beneath the surface layer is stratified. Just beneath the surface layer is a layer of olive-gray sandy gravel about 10 inches thick. This layer is underlain by a layer of dark grayish-brown gravelly coarse sand about 5 inches thick. The next layer is olive-gray sandy gravel about 30 inches thick. Just beneath this layer is grayish-brown coarse sand that extends to a depth of 60 inches or more.

In the surface layer, permeability is moderate and the available water capacity is high. Below the surface layer, permeability is rapid and the available water capacity is very low. The average available water capacity is very low. The water table is very deep.

Typical profile of a Coe gravelly loam (140 feet west and 300 feet south of the northeast corner of sec. 25, T. 158 N., R. 57 W.):

A1—0 to 5 inches, very dark grayish-brown (2.5Y 3/2) gravelly loam, black (10YR 2/1) when moist; fine crumb structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; 20 to 25 percent of horizon is shale and igneous gravel; abrupt, wavy boundary.

IIC1—5 to 15 inches, olive-gray (5Y 4/2) sandy gravel, dark olive gray (5Y 3/2) when moist; single grain; loose when dry or moist; 50 percent of horizon is shale gravel; slightly calcareous; abrupt, smooth boundary.

IIIC2—15 to 20 inches, dark grayish-brown (2.5Y 4/2) gravelly coarse sand, dark brown (10YR 4/3) when moist; single grain; loose when dry or moist; 40 percent of horizon is gravel, and 60 percent is sand that is mostly crystalline; slightly calcareous; clear, smooth boundary.

IIIC3—20 to 26 inches, olive-gray (5Y 4/2) sandy gravel, dark olive gray (5Y 3/2) when moist; single grain; loose when dry or moist; 60 percent of horizon is shale gravel, and 40 percent is shale sand; slightly calcareous.

IIIC4—36 to 50 inches, olive-gray (5Y 4/2) sandy gravel, dark olive gray (5Y 3/2) when moist; single grain; loose when dry or moist; 65 percent of horizon is shale gravel, and 35 percent is shale sand; slightly calcareous.

IVC5—50 to 60 inches, grayish-brown (2.5Y 5/2) coarse sand, dark olive gray (5Y 3/2) and pale brown (10YR 6/3) when moist; single grain; loose when dry or moist; 10 percent of horizon is gravel, and 90 percent is sand, shale, and crystalline material; slightly calcareous.

The A horizon ranges from 5 to 10 inches in thickness, and its texture is loam or gravelly loam. Shale gravel and shale sand are predominant in the C horizon, but in some places as much as 30 percent of the C horizon is crystalline gravel and sand.

The Coe soils are shallower over gravel and sand than the Brantford soils, and they lack the B horizon that is typical in the profile of those soils. Their C horizon contains more shale gravel and shale sand than does that of the Sioux soils.

Coe soils (6 to 30 percent slopes) (Ce).—These are the only soils of the Coe series mapped in Walsh County. They are on ridges and terraces consisting mainly of water-deposited shale gravel and shale sand. Thickness of the surface layer and depth to the gravelly and sandy substratum are variable because of differences in the steepness of the slope and in the amount of erosion that has taken place.

The chief limitations to use of these soils for crops are the moderate to high susceptibility to soil blowing and water erosion, and droughtiness caused by the shallow root zone and the low available water capacity of the substratum. About half of the acreage is cultivated, and the rest is in native grass. (Capability unit VIs–SwG; windbreak site 10)

Colvin Series

The Colvin series consists of deep, poorly drained, calcareous soils that have formed in medium-textured and moderately fine textured material deposited by water. These soils are on the glacial lake plain, in shallow depressions where runoff accumulates during wet periods. The native vegetation was tall prairie grasses and wetland grasses.

In a typical profile, the surface layer is very dark gray silty clay loam that is about 11 inches thick and is mottled with very dark brown in the lower part. Just beneath the surface layer is a layer, about 19 inches thick, that is strongly calcareous and contains a large amount of lime. This layer is very dark gray silty clay loam in the uppermost 3 inches and is pale-olive silt loam in the lower part. It contains distinct brown and light olive-brown mottles that increase in number with increasing depth. Stratified, mottled, olive silty clay loam and clay deposited by water are below the layer that contains a large amount of lime.

Permeability is moderately slow, and the available water capacity is high. The water table is at the surface or is within 5 feet of the surface during wet periods.

Typical profile of Colvin silty clay loam in a cultivated field (150 feet west and 545 feet north of the southeast corner of sec. 28, T. 157 N., R. 52 W.):

Ap—0 to 7 inches, very dark gray (N 3/0) silty clay loam, black (N 2/0) when moist; cloddy; firm when moist, sticky and plastic when wet; slightly calcareous; abrupt, smooth boundary.

A1—7 to 11 inches, very dark gray (N 3/0) silty clay loam, black (N 2/0) when moist; common, coarse, faint, very dark brown mottles; strong, very fine, blocky structure; firm when moist, very sticky and very plastic when wet; slightly calcareous; abrupt, irregular

boundary; tongues of material from this horizon extend downward to a depth of 18 to 22 inches.

C1ca—11 to 14 inches, very dark gray (5Y 3/1) silty clay loam, very dark gray (10YR 3/1) when moist; weak, very thin, platy structure breaking to moderate, very fine, subangular blocky structure; firm when moist, very sticky and very plastic when wet; strongly calcareous; abrupt, broken boundary.

C2ca—14 to 19 inches, pale-olive (5Y 6/3) silt loam, olive (5Y 5/3) when moist; a few, fine, distinct, brown mottles; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; many root channels; few nodules of manganese; clear, broken boundary.

C3ca—19 to 30 inches, pale-olive (5Y 6/4) silt loam, olive (5Y 5/3) when moist; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles and many, coarse, prominent, yellowish-brown (10YR 5/6) mottles when moist; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; common nodules of manganese; clear, smooth boundary.

C4—30 to 44 inches, olive (5Y 5/3) silty clay loam, olive brown (2.5Y 4/4) when moist; common, medium, distinct, brown and gray mottles and many, medium, prominent, dark yellowish-brown (10YR 4/4) mottles when moist; moderate, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; slightly calcareous; many root channels; few nodules of lime.

IIC5—44 to 60 inches, olive (5Y 5/3) clay; many, coarse, prominent, brown and gray mottles, light olive brown (2.5Y 5/4) when moist, and many, coarse, prominent, dark yellowish-brown (10YR 4/4) mottles; massive; very firm when moist, very sticky and very plastic when wet; slightly calcareous; few nodules of lime and iron.

The A horizon ranges from silty clay loam to silt loam in texture and from 7 to 15 inches in thickness. The Cca horizon ranges from pale olive to gray or very dark gray in color and from 10 to 22 inches in total thickness. Below the C3ca horizon, the soil material is dominantly silty clay loam, but it contains numerous thin layers of interbedded silt loam, silty clay, and clay that are mostly olive or olive gray but that contain many prominent mottles of brown and gray. In some places the profile is nonsaline throughout. In others the profile is moderately saline throughout.

The Colvin soils have more clay in the uppermost 40 inches of their profile than the Borup soils. They are more poorly drained than the Bearden soils, and they lack the glacial till C horizon that underlies the Manfred soils.

Colvin silt loam (0 to 3 percent slopes) (Cf).—This soil is in shallow depressions on the glacial lake plain. Water ponds on the surface for short periods during wet weather. The profile is similar to the one described as representative of the series, except that the surface layer is silt loam.

Included with this soil in mapping were areas of Bearden silty clay loam that make up from 15 to 20 percent of the acreage in some areas of this mapping unit. Also included were a few areas of moderately saline soils.

Poor drainage is the chief limitation to use of this Colvin soil for crops. In many places where outlets are available, however, drainage has been improved by constructing surface drains. Much of the acreage has been drained and is used for cultivated crops. Where drained, this soil is suited to all the field crops, hay crops, and pasture plants commonly grown in the county. (Capability unit IIw-6; windbreak site 2)

Colvin silty clay loam (0 to 3 percent slopes) (Ch).—This soil is in shallow depressions on the glacial lake plain. Water ponds on the surface for short periods during wet weather. The profile is the one described as representative of the series.

Included with this soil in mapping were areas of Perella silty clay loam that together make up as much as 10 percent of the acreage in this mapping unit.

The chief limitation to use of this Colvin soil for crops is poor drainage. In many places where outlets are available, drainage has been improved by installing surface drains. Much of the acreage has been drained and is used for cultivated crops. If this soil is drained, it is suited to all the field crops, hay crops, and pasture plants commonly grown in the county. (Capability unit IIw-6; windbreak site 2)

Colvin silty clay loam, very wet (0 to 3 percent slopes) (Co).—This soil is in depressions on the glacial lake plain. Water ponds on the surface in spring and during most of the summer. Because this soil is in deeper depressions and is more difficult to drain than Colvin silty clay loam, it was mapped separately from that soil, although the two soils have similar profiles.

Included with this soil in mapping were areas of Colvin soils that have a surface layer of silt loam. Also included were a few small areas of a soil that is somewhat poorly drained, that has a clay subsoil high in content of sodium, and that lacks the high content of lime typical of the Colvin soils.

Poor drainage is the chief limitation to use of this Colvin soil for crops. In most places artificial drainage is not practical. (Capability unit Vw-WL; in windbreak site 2 if drained, but in windbreak site 10 if undrained)

Cresbard Series

The Cresbard series consists of moderately well drained soils that contain a claypan. These soils are on glacial till plains, where they have formed in calcareous glacial till. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is very dark gray loam about 7 inches thick. The subsoil is about 9 inches thick. It is mostly dark grayish-brown dense clay, but it is light clay loam in the uppermost 2 inches, where many thin, vertical tongues of loamy material extend downward from the surface layer. Just below the subsoil is a layer of clay loam that is about 24 inches thick and contains a large amount of lime. The upper part of this layer is white and is very strongly calcareous. The lower part is pale yellow and is strongly calcareous. Underlying this limy material is a layer of pale-yellow, mottled, slightly calcareous clay loam glacial till that extends to a depth of 60 inches or more.

These soils have moderate permeability in the surface layer and moderately slow permeability in the subsoil and the substratum. They have high available water capacity and a deep water table.

Typical profile of a Cresbard loam in a cultivated area (0.25 mile north and 60 feet west of the southeast corner of sec. 9, T. 156 N., R. 57 W.):

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; strong, coarse, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

B&A—E to 9 inches, dark grayish-brown (10YR 4/2) light clay loam, very dark brown (10YR 2/2) when moist; strong, coarse, prismatic structure breaking to strong, medium, angular blocky structure; surfaces of peds are coated with grayish-brown silt and clay that are very

dark grayish brown when moist; hard when dry, firm when moist, sticky and plastic when wet; abrupt, wavy boundary.

B2t—9 to 16 inches, dark grayish-brown (10YR 4/2) clay, very dark brown (10YR 2/2) when moist; strong, coarse and medium, columnar structure breaking to strong, medium and fine, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; continuous, distinct clay films on all the surfaces of peds; clear, wavy boundary.

C1ca—16 to 23 inches, white (5Y 8/2) clay loam, olive (5Y 5/3) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; contains a few crystals of salt; gradual, wavy boundary.

C2ca—23 to 40 inches, pale-yellow (5Y 7/3) clay loam, olive (5Y 5/4) when moist; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; gradual, wavy boundary.

C3—40 to 60 inches, pale-yellow (5Y 7/3) clay loam, olive (5Y 4/3) when moist; a few, fine, faint, strong-brown (7.5YR 5/8) mottles; massive; slightly hard when dry, friable when moist, sticky and plastic when wet; slightly calcareous.

The A horizon ranges from 6 to 9 inches in thickness. In places the B2t horizon is very dark grayish brown.

The Cresbard soils have a B horizon that is more slowly permeable, contains more clay, and has stronger structure than the B horizons of the Barnes and Svea soils. They have a thicker A horizon than the Cavour soils, and they lack the Cca horizon immediately below the A horizon that is typical in the profile of the Hamerly soils.

In Walsh County the Cresbard soils were mapped only in complexes with the Hamerly and Svea soils.

Divide Series

The Divide series consists of soils that are moderately well drained and somewhat poorly drained. These soils have formed in loamy glacial outwash that was deposited over gravel and coarse sand. They are on terraces and outwash plains, where they have formed under medium and tall prairie grasses.

In a typical profile, the surface layer is very dark gray, calcareous loam about 8 inches thick. Just beneath the surface layer is a layer of light brownish-gray, very strongly calcareous clay loam that contains a large amount of lime and is about 12 inches thick. Next is a layer of white gravel and coarse sand that also contains a large amount of lime and is about 16 inches thick. Below is a layer of gray, calcareous shaly gravel and coarse sand that extends to a depth of 60 inches or more.

In the surface layer and the layer just beneath the surface layer, permeability is moderate and the available water capacity is high. In the underlying gravel and coarse sand, permeability is rapid and the available water capacity is very low. The average available water capacity is low. The water table rises to within 3 to 5 feet of the soil surface during wet periods.

Typical profile of Divide loam, level, in a cultivated field (260 feet east and 120 feet south of the northwest corner of sec. 9, T. 155 N., R. 56 W.):

A1—0 to 8 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; weak, fine, granular structure; friable when moist, slightly sticky and slightly plastic when wet; calcareous; abrupt, wavy boundary.

C1ca—8 to 20 inches, light brownish-gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) when moist; a few, fine, faint, brown mottles; moderate, very fine, angular blocky structure; friable when moist, sticky and plastic when wet; very strongly calcareous; abrupt, wavy boundary.

IIC2ca—20 to 36 inches, white (2.5Y 8/2) gravel and coarse sand, light brownish gray (2.5Y 6/2) when moist; single grain; strongly calcareous; clear boundary.

IIC3—36 to 60 inches, gray (N 6/0) shaly gravel and coarse sand, white (5Y 8/2), pale brown (10YR 7/3), and olive gray (5Y 4/2) when moist; a few coarse mottles; single grain; calcareous.

Texture of the A horizon ranges from loam to sandy loam or fine sandy loam. In places texture of the C1ca horizon is loam. Depth to gravel and coarse sand ranges from 14 to 28 inches. In some places the IIC horizons are coarse sand, gravelly sand, gravelly loam, and gravel. In others shaly sand and shaly gravel make up from 20 to 60 percent of these horizons.

Unlike the Ulen soils, the Divide soils are underlain by IIC horizons of coarse sand and gravel. They have a Cca horizon closer to the surface than the Renshaw soils, and they lack the B horizon that is typical of the Renshaw and Brantford soils. Divide soils are deeper over sand and gravel than the Sioux soils, and they are not excessively drained like those soils.

Divide loam, level (0 to 3 percent slopes) (DdA).—This soil is on low beaches, glacial outwash plains, and gravelly stream terraces. It is the only soil of the Divide series mapped in Walsh County.

Included with this soil in mapping were small areas that are gently sloping and small areas that are moderately eroded. These included areas have a thinner surface layer than this Divide soil because they have lost part of their original surface layer through soil blowing.

This Divide soil is used mainly for cultivated crops, but it is suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitations to its use for crops are droughtiness, caused by the moderate depth of the root zone over sand and gravel, and the very low available water capacity of the substratum. An additional major limitation is the moderate to high susceptibility to soil blowing. (Capability unit IIIs-4L; windbreak site 2)

Edgeley Series

The Edgeley series consists of deep, well-drained soils that have formed in shaly glacial till over bedded shale. The native vegetation was medium and tall prairie grasses and a few scattered trees and shrubs.

In a typical profile, the surface layer is very dark gray loam about 5 inches thick. The subsoil is about 20 inches thick and consists of dark grayish-brown clay loam in the upper part and of olive-gray, mottled shaly clay loam in the lower part. The next layer is light olive-gray, mottled shaly clay loam glacial till about 21 inches thick. This is underlain by dark-gray bedded shale.

Permeability is moderate in the surface layer and the subsoil, and it is moderately slow in the substratum. The available water capacity is high. These soils have a very deep water table.

Typical profile of Edgeley loam, nearly level (0.2 mile north and 50 feet west of St. Peters Church, sec. 11, T. 157 N., R. 57 W.):

A1—0 to 5 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist, weak, fine, subangular blocky structure breaking to moderate, fine, crumb structure; slightly hard when dry, very friable when moist, slightly plastic when wet; very high content of organic matter; abrupt boundary.

B2—5 to 13 inches, dark grayish-brown (2.5Y 4/2) clay loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, medium, prismatic structure breaking to

strong, fine, subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; 15 percent of horizon consists of fragments of broken shale larger than 2 millimeters in diameter; clear boundary.

B3—13 to 25 inches, olive-gray (5Y 5/2) shaly clay loam, dark olive gray (5Y 3/2) when moist; common, fine, faint mottles; weak, medium, prismatic structure breaking to strong, fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; 20 to 25 percent of horizon is fragments of broken shale larger than 2 millimeters in diameter; clear boundary.

C—25 to 46 inches, light olive-gray (5Y 6/2) shaly clay loam, olive gray (5Y 4/2) when moist; common, fine, faint, yellowish-brown (10YR 5/6) mottles and common, fine, faint mottles when moist; moderate, fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; 40 to 50 percent of horizon is broken fragments of shale larger than 2 millimeters in diameter.

IIR—46 to 56 inches, dark-gray (5Y 4/1) bedded shale, dark olive gray (5Y 3/2) when moist; shale breaks to horizontal fragments that are 2 to 20 millimeters in diameter; few nodules of lime.

Texture of the A horizon is loam to silt loam. In places the B2 horizon is very dark grayish brown and has clay films on the surfaces of some peds. The B3 horizon is shaly loam in some areas. Thickness of the solum ranges from 17 to 36 inches. The content of particles of weathered shale in the shaly glacial till ranges from 20 to 50 percent. Depth to bedded shale ranges from 36 to 60 inches, but it is generally about 48 inches. In a few places, a layer of gravel and coarse sand that is 1 to 6 inches thick lies immediately above the bedded shale of the IIR horizon.

Unlike the Barnes, Svea, Waukon, and Lankin soils, the Edgeley soils are underlain by bedded shale at some depth within 60 inches of the surface. They are deeper over shale than the Kloten soils. The Edgeley soils lack the C horizon of shaly gravel that is typical of the Brantford and Vang soils.

Edgeley loam, nearly level (0 to 3 percent slopes) (EbA).—This soil is adjacent to deep drainageways. It has the profile described as representative of the series. Depth to bedded shale is generally between 40 and 48 inches.

Included with this soil in mapping were a few areas where bedded shale is at a depth of less than 40 inches, and some areas where bedded shale is below a depth of 48 inches. Also included were a few small areas of Cresbard and Cavour soils.

Climate is the chief limitation to use of this Edgeley soil for crops. Soil blowing is also a slight hazard, and water erosion is a slight hazard where the slopes are the longest and steepest. This soil is suited to the commonly grown field crops, hay crops, and pasture plants, however, and nearly all of the acreage is cultivated. (Capability unit IIc–6; windbreak site 3)

Edgeley loam, gently undulating (3 to 5 percent slopes) (EbB).—This soil is adjacent to drainageways. Its profile is similar to the one described as representative of the series, except that in most places bedded shale is at some depth between 36 and 48 inches.

Included with this soil in mapping were small areas in which shale is at a depth of 36 inches or less, and these areas make up about 25 percent of the acreage in this mapping unit. Also included were a few areas in which shale is below a depth of 48 inches. Other inclusions consist of moderately eroded areas where part of the surface layer has been lost, mainly as the result of water erosion.

This Edgeley soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. This soil is chiefly limited in use for crops by its susceptibility to water erosion if it is cultivated, but it is also slightly susceptible to soil blowing. During intense rainstorms in summer, water erosion is difficult to control in fields that are summer fallowed. (Capability unit IIe–6; windbreak site 3)

Edgeley loam, undulating (6 to 12 percent slopes) (EbC).—This soil is along drainageways. Its dominant slopes are between 6 and 8 percent, but the slopes are as steep as 12 percent in some places. The profile is similar to the one described as representative of the series, except that shale is at some depth between 36 and 48 inches.

Included with this soil in mapping were small areas in which shale is at a depth of 36 inches or less, and these areas make up about 25 percent of the acreage in this mapping unit. Also included were moderately eroded areas that together make up about 20 percent of the acreage in the mapping unit.

This Edgeley soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitation to its use for crops is susceptibility to water erosion, but soil blowing is also a slight hazard. During intense rainstorms in summer, areas in summer fallow are especially susceptible to water erosion. (Capability unit IIIe–6; windbreak site 3)

Embden Series

The Embden series consists of deep, moderately well drained soils on sandy plains. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is very dark gray sandy loam about 11 inches thick. The subsoil is about 13 inches thick and is fine sandy loam that is dark gray in the upper part and is brown in the lower part. Just below the subsoil is a layer of light-gray loamy sand that is about 20 inches thick and contains a large amount of lime. The next layer is pale-brown loamy fine sand about 9 inches thick. It is underlain by pale-brown fine sand that extends to a depth of 60 inches or more.

Permeability is moderately rapid. The available water capacity of the surface layer and the subsoil is moderate to high, and that of the substratum is low. The average available water capacity is low. These soils have a very deep water table.

Typical profile of Embden sandy loam, level, in a cultivated field (800 feet west and 250 feet south of the northeast corner of sec. 25, T. 156 N., R. 55 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) when moist; weak, medium, subangular blocky structure breaking to weak, fine, granular structure; friable when moist; abrupt, smooth boundary.

A1—6 to 11 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) when moist; moderate, medium, subangular blocky structure breaking to weak, fine, subangular blocky structure; friable when moist; clear, smooth boundary.

B2—11 to 19 inches, dark-gray (10YR 4/1) fine sandy loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure breaking to weak, fine, angular blocky structure; friable when moist, slightly plastic when wet; clear, smooth boundary.

B3—19 to 24 inches, brown (10YR 5/3) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, subangular blocky structure breaking to weak, very fine, crumb structure; friable when moist, slightly plastic when wet; about 2 percent, by volume,

consists of pebbles larger than 2 millimeters in diameter; abrupt, wavy boundary.

C1ca—24 to 32 inches, light-gray (2.5Y 7/2) loamy sand, grayish brown (2.5Y 5/2) when moist; weak, fine, subangular blocky structure breaking to single grain; friable when moist; very strongly calcareous; about 10 percent, by volume, consists of pebbles larger than 2 millimeters in diameter; clear, wavy boundary.

C2ca—32 to 44 inches, light-gray (10YR 7/2) loamy sand, grayish brown (2.5Y 5/2) when moist; single grain; very friable when moist; strongly calcareous; clear, wavy boundary.

C3—44 to 53 inches, pale-brown (10YR 6/3) loamy fine sand, yellowish brown (10YR 5/4) when moist; single grain; very friable when moist; calcareous.

C4—53 to 60 inches, pale-brown (10YR 6/3) fine sand, dark brown (10YR 4/3) when moist; single grain; loose when dry or moist; weakly calcareous.

The A horizon ranges from 6 to 13 inches in thickness, from sandy loam to loam in texture, and from very dark gray to very dark grayish brown in color. The B horizon is 7 to 17 inches thick, and it is brown to dark gray. The Cca horizon is at some depth between 22 and 30 inches, and it is 10 to 20 inches thick. Texture of the Cca horizon ranges from sand to sandy clay loam. In some places the C3 and C4 horizons contain a large amount of shaly sand.

The Embden soils contain less sand than the Hecla soils, and unlike the Hecla soils, they have a B2 horizon. Their A horizon is thinner and less sandy than that of the Maddock soils. The Embden soils are better drained than the Ulen and Arveson soils.

Embden sandy loam, level (0 to 3 percent slopes) (EmA).—This soil is on lacustrine plains and beach lines. It has the profile described as representative of the series.

Included with this soil in mapping were small areas in which coarse sand and gravel are below a depth of 3 feet.

This Embden soil is highly susceptible to soil blowing, and its substratum has low available water capacity. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and nearly all of the acreage is cultivated. (Capability unit IIIe–3; windbreak site 1)

Embden sandy loam, gently undulating (3 to 6 percent slopes) (EmB).—This soil is on beach lines. It has a profile similar to the one described as representative of the series, except that the surface layer is lighter colored and both the surface layer and the subsoil are thinner.

Included with this soil in mapping were areas that are underlain by lacustrine loam or clay loam. These places are mainly in drainageways that cross the glacial till plain. Also included were areas that are underlain by coarse sand and gravel.

This Embden soil is highly susceptible to soil blowing, and the substratum has low available water capacity. In spring, when thawing occurs, water erosion is also a slight hazard. Nevertheless, this soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. A few areas are in pasture or hay. (Capability unit IIIe–3; windbreak site 1)

Embden sandy loam, sloping (6 to 9 percent slopes) (EmC).—This soil is on the side slopes of stream channels that dissect the nearly level lacustrine plain. Its profile is similar to the one described as representative of the series, except that the surface layer is thinner in most places. Thickness of the surface layer varies considerably, however, because part of the original surface layer has been lost through erosion in some areas and additional soil material has been deposited in others.

Some areas are cultivated, but this soil is mainly in pasture or hay. It has low available water capacity in the substratum, is highly susceptible to soil blowing, and is slightly susceptible to water erosion when thawing occurs in spring. This soil is suited, however, to the field crops, hay crops, and pasture plants commonly grown in the county. (Capability unit IIIe–3; windbreak site 1)

Embden loam, level (0 to 3 percent slopes) (EnA).—This soil is on lacustrine plains. It has a profile similar to the one described as representative of the series, except that the surface layer is darker colored, has a loam texture, and contains more organic matter than the one in the profile described as representative.

Included with this soil in mapping were small areas that are moderately eroded as a result of soil blowing. These areas have a thinner, slightly coarser textured surface layer than normal for Embden soils.

This Embden soil is moderately susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and nearly all of the acreage is cultivated. (Capability unit IIe–5; windbreak site 1)

Fairdale Series

The Fairdale series consists of deep, moderately well drained soils that have formed in calcareous, stratified alluvium. These soils are on flood plains and natural levees. The native vegetation was tall prairie grasses and deciduous trees and shrubs.

In a typical profile, the surface layer is grayish-brown silt loam about 3 inches thick. Below the surface layer is stratified calcareous material that is variable in color, texture, and thickness. Typically, the layer just beneath the surface layer is light-gray very fine sand about 3 inches thick. The next layer is grayish-brown silt loam about 2 inches thick. This layer is underlain by the surface layer of a buried soil, which consists of dark-gray silt loam about 3 inches thick. Beneath the buried layer is very dark grayish-brown and dark grayish-brown alluvium that has a texture of fine sandy loam, silt loam, and silty clay loam. The alluvial material extends to a depth of 60 inches or more.

Where these soils have formed in alluvium that has a texture of silt loam, they have moderate premeability. Where they have formed in alluvium that has a texture of silty clay loam, they have moderately slow permeability. These soils have high available water capacity. Except during periods of flooding, the water table is generally below a depth of 5 feet.

Typical profile of Fairdale silt loam, occasionally flooded (0.15 mile north of the southeast corner of sec. 18, T. 157 N., R. 54 W.):

A1—0 to 3 inches, grayish-brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, very fine, crumb structure; very friable when moist, slightly sticky and slightly plastic when wet; calcareous; abrupt boundary.

IIC1—3 to 6 inches, light-gray (10YR 7/1) very fine sand; gray (10YR 6/1) when moist; single grain; loose when dry or moist; moderately calcareous; abrupt boundary.

IIIC2—6 to 8 inches, grayish-brown (2.5Y 5/2) silt loam; dark grayish brown (2.5Y 4/2) when moist; weak, thin strata of alluvium; friable when moist; moderately calcareous; abrupt boundary.

A1b—8 to 11 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; strong, medium, granular structure; very friable when moist; very weakly calcareous; abrupt boundary.

IVC3—11 to 60 inches, very dark grayish-brown (10YR 3/2), grading to dark grayish brown (10YR 4/2), alluvial material; stratified very fine sandy loam, silt loam, and silty clay loam; very friable when moist; moderately calcareous.

The A horizon ranges from loam to silty clay loam in texture and from 3 to 8 inches in thickness. In places it is dark grayish brown. Below the A horizon, the texture changes abruptly to stratified very fine sand, very fine sandy loam, silt loam, and silty clay loam. In places the A horizon is noncalcareous, but in most places the rest of the profile is slightly calcareous or moderately calcareous. Lime is generally disseminated throughout the soil mass, but it appears as threads and fine nodules in some of the deeper strata.

The Fairdale soils are lighter colored and contain less organic matter than the LaPrairie soils with which they are associated. They are better drained than the Lamoure soils, and they are coarser textured than the Cashel and Wahpeton soils.

Fairdale silt loam (0 to 3 percent slopes) (Fa).—This soil is on natural levees of the Park River. It is subject to flooding in about 3 years out of 10. When flooding occurs, the floodwaters completely cover the flood plain of the river and cover part of the adjacent glacial lake plain. Surface drainage and internal drainage are good enough, however, that this soil can be cultivated soon after the floodwaters recede. The content of clay in this soil is lowest in the west-central part of the county, and it increases toward the eastern part. The profile is similar to the one described as representative of the series, except that the surface layer is thicker, is more calcareous throughout, and lacks the well-defined stratification typical of Fairdale soils on flood plains.

Included with this soil in mapping were some areas where the surface layer is silty clay loam. Also included were areas of soils in shallow, meandering drainageways that dissect areas of this soil but that mostly run parallel to the natural levees.

Climate is the chief limitation to use of this Fairdale soil for crops, but this soil is also slightly susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIc–6; windbreak site 1)

Fairdale silt loam, gently sloping (3 to 5 percent slopes) (FaB).—This soil is on side slopes bordering river channels and intermittent drainageways. It is subject to occasional flooding, but drainage is good enough that this soil can be cultivated soon after the floodwaters recede. The profile is similar to the one described as representative of the series, except that the surface layer is lighter colored and contains less organic matter.

Included with this soil in mapping were small areas of LaPrairie silt loam, gently sloping, and small areas where the surface layer is silty clay loam.

This Fairdale soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Susceptibility to water erosion is the chief limitation to use of this soil for crops, but soil blowing is also a slight hazard. (Capability unit IIe–6; windbreak site 1)

Fairdale silt loam, occasionally flooded (0 to 3 percent slopes) (Fd).—This soil is on flood plains. In spring it is subject to occasional flooding, but it has good enough drainage that tillage is feasible soon after the floodwaters recede. The profile is the one described as representative of the series.

Included with this soil in mapping were small areas of LaPrairie silt loam and areas of soils in a few small stream channels. Other inclusions consist of areas in which the surface layer is silty clay loam.

The chief limitation to use of this Fairdale soil for crops is the unfavorable climate, but susceptibility to soil blowing is also a slight limitation. About three-fourths of the acreage is suited to the commonly grown field crops, hay crops, and pasture plants, and it has been cleared for cultivation. (Capability unit IIc–6; windbreak site 1)

Fairdale and LaPrairie soils, channeled (0 to 3 percent slopes) (Fe).—About 60 percent of this mapping unit consists of Fairdale silt loam and Fairdale silty clay loam, and the rest consists mainly of LaPrairie silt loam and LaPrairie silty clay loam. These soils occur in such complex patterns that it was not practical to map them separately. They are on channeled flood plains of the Park and Forest Rivers. The areas include scoured spots and places where floodwaters have recently deposited silt. The Fairdale soil has a profile similar to the one described as representative of the Fairdale series. The LaPrairie soil has a profile similar to the one described as representative of the LaPrairie series, except that the surface layer is thinner.

Included with these soils in mapping were areas of soils in the many shallow, abandoned stream channels and oxbows; areas of soils on wide flood plains along the main channels; and areas of soils on narrow flood plains along meanders of the main channels. Other inclusions along streambeds west of Highway 32 consist of areas of soils that contain shale gravel and many glacial boulders and numerous springs.

Because of the irregular topography and frequency of flooding, soils of this mapping unit are mainly in native vegetation. Undisturbed areas have a thick undergrowth of weeds and brush. The vegetation in areas used for pasture consists mainly of bluegrass and of stands of timber of varying densities. (Capability unit VIe–Si; windbreak site 10)

Fargo Series

The Fargo series consists of deep, poorly drained soils in shallow depressions of glacial lake plains, on levees along streams, and on streambanks. These soils have formed in fine-textured lacustrine sediment. The native vegetation was mainly medium and tall prairie grasses. It was tall prairie grasses where the Fargo soils were mapped with Hegne soils.

In a typical profile, the surface layer is black silty clay about 9 inches thick. The subsoil is about 13 inches thick and is also silty clay. It is black in the upper part and is very dark gray in the lower part. The substratum is stratified silty clay lacustrine sediment that extends to a depth of 56 inches or more. The upper part of the substratum is dark grayish brown, the middle part is mottled grayish brown, and the lower part is mottled grayish brown and light olive brown.

These soils have slow permeability and high available water capacity. They have a seasonal high water table, which rises to the surface or is within 5 feet of the surface during wet periods.

Typical profile of Fargo silty clay, nearly level, in a cultivated field (0.25 mile south and 75 feet west of the northeast corner of sec. 36, T. 157 N., R. 52 W.):

Ap—0 to 6 inches, black (10YR 2/1) silty clay, black (10YR 2/1) when moist; cloddy, breaking to strong, very fine, subangular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; slightly calcareous; abrupt, smooth boundary.

A1—6 to 9 inches (plowpan), black (N 2/0) silty clay, black (N 2/0) when moist; moderate, medium, angular blocky structure breaking to strong, fine, angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; slightly calcareous; abrupt, smooth boundary.

B2—9 to 17 inches, black (N 2/0) silty clay, black (N 2/0) when moist; moderate, medium, prismatic structure breaking to strong, very fine, subangular blocky structure; surfaces of peds are very shiny; hard when dry, firm when moist, very sticky and very plastic when wet; abrupt, wavy boundary.

B3—17 to 22 inches, very dark gray (10YR 3/1) silty clay, very dark gray (10YR 3/1) when moist; moderate, medium, prismatic structure breaking to strong, very fine, subangular blocky structure; surfaces of peds are shiny; hard when dry, firm when moist, very sticky and very plastic when wet; clear, irregular boundary.

C1—22 to 28 inches, dark grayish-brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) when moist; moderate, fine, prismatic structure breaking to strong, very fine, angular blocky structure; slightly hard when dry, firm when moist, very sticky and very plastic when wet; slightly calcareous; abrupt boundary.

C2ca—28 to 42 inches, grayish-brown (2.5Y 5/2) silty clay, olive brown (2.5Y 4/4) when moist; few, fine, faint mottles; strong, fine and medium, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; strongly calcareous; abrupt boundary.

C3—42 to 56 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) silty clay, olive brown (2.5Y 4/4) when moist; common, medium, distinct, yellowish-brown mottles, and intensity of mottling increases at a depth of about 56 inches; weak, fine, angular blocky structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; few roots to a depth of 56 inches; calcareous and contains a few nodules of segregated lime.

In places the B2 horizon is clay. Thickness of the C2ca horizon ranges from 14 to 22 inches.

Unlike the Hegne and Grano soils, the Fargo soils lack a Cca horizon near the surface. They are more poorly drained than the Cashel and Wahpeton soils.

Fargo silty clay, nearly level (0 to 3 percent slopes) (FfA).—This soil occupies areas that are commonly flooded by waters of the Forest and Red Rivers. It has the profile described as representative of the series.

Included with this soil in mapping were a few areas of wet soils in depressions. Also included were some narrow areas of Wahpeton silty clay on levees along streams.

This Fargo soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and nearly all of the acreage is cultivated. The poor natural drainage is the chief limitation to use of this soil for crops, but this soil is also moderately to highly susceptible to soil blowing if it is cultivated. Where outlets are available, drainage can be improved in some places by constructing field drains. (Capability unit IIwe-4; windbreak site 1)

Fargo silty clay, depressional (0 to 1 percent slopes) (Fg).—This soil is in depressions that range from about one-half acre to 45 acres in size. Some areas of less than 2 acres are mapped as inclusions with other soils.

Included with this soil in mapping were small areas of Grano soils. Also included were small areas of a soil that has a subsurface layer of silt loam that is 2 to 13 inches thick, and that has a clay subsoil, which is at a greater depth than typical for the subsoil of the Fargo soils.

This Fargo soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and nearly all of the acreage is cultivated. The chief limitation to use of this soil for crops is the poor natural drainage, but this soil is also moderately to highly susceptible to soil blowing if it is cultivated. (Capability unit IIw-4; windbreak site 2)

Fargo-Hegne silty clays, level (0 to 2 percent slopes) (FhA).—Soils of this mapping unit are on natural levees along streams, where the rate of runoff is medium. About 60 percent of the acreage is Fargo silty clay, 35 percent is Hegne silty clay, and the rest consists of other soils. The soils occur in such a complex pattern that it was not practical to map them separately.

Included with these soils in mapping were some areas in which Hegne clay is the dominant soil.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. These soils are moderately to highly susceptible to soil blowing if they are cultivated, but the chief limitation to their use for crops is their poor natural drainage. In some areas where outlets are available, drainage has been improved by constructing field drains. (Capability unit IIwe-4; windbreak site 1)

Fargo-Hegne silty clays, gently sloping (3 to 5 percent slopes) (FhB).—Soils of this mapping unit are on the side slopes of stream channels that have cut into the glacial lake plain. About 50 percent of the acreage is Fargo silty clay, 40 percent is Hegne silty clay, and the rest is other soils. The profiles of these soils are similar to the ones described as typical for their respective series, except that the surface layer is thinner as a result of soil blowing and water erosion. In places part of the subsoil has been mixed in the plow layer through tillage.

Included with these soils in mapping were small areas of Hattie silty clay.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. The soils are moderately to highly susceptible to soil blowing. They are also susceptible to water erosion during periods when runoff occurs in spring, and during storms of high intensity in summer. (Capability unit IIe-4; windbreak site 1)

Fossum Series

The Fossum series consists of soils that are deep and poorly drained. These soils are in shallow depressions in interbeach areas, on outwash plains, and on deltas. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is about 14 inches thick. It consists of very dark gray, strongly calcareous loam in the upper part and of dark gray, strongly calcareous sandy loam in the lower part. Just below the surface layer is a layer of gray, mottled, very strongly calcareous sandy loam that is about 5 inches thick and contains a large amount of lime. The next layer is grayish-brown,

mottled fine sand about 21 inches thick. It is underlain by a layer of light-gray, mottled sand, which extends to a depth of about 54 inches. Below this sand is a layer of light brownish-gray, mottled gravelly coarse sand that extends to a depth of 66 inches or more.

These soils have moderate permeability and moderate available water capacity in the surface layer and in the layer that contains a large amount of lime. They have moderately rapid permeability and low available water capacity below the layer that contains a large amount of lime. The average available water capacity for the entire profile is low. A seasonal high water table is at the surface or is within 3 feet of the surface during wet periods.

Typical profile of a Fossum loam (220 feet east and 800 feet north of the southwest corner of sec. 21, T. 155 N., R. 55 W.):

A11ca—0 to 9 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; weak, fine, crumb structure; soft when dry, friable when moist, slightly plastic when wet; strongly calcareous; abrupt, wavy boundary.

A12ca—9 to 14 inches, dark-gray (N 4/0) sandy loam, very dark gray (N 3/0) when moist; moderate, fine, crumb structure; soft when dry, friable when moist, slightly plastic when wet; strongly calcareous.

C1ca—14 to 19 inches, gray (N 6/0) sandy loam, dark gray (N 4/0) when moist; a few, fine, faint, gray mottles; weak, fine, crumb structure; soft when dry, very friable when moist, plastic and slightly sticky when wet; very strongly calcareous; clear, wavy boundary.

C2—19 to 40 inches, grayish-brown (2.5Y 5/2) fine sand, dark grayish brown (10YR 4/2) when moist; a few, fine, faint, brown mottles and many, coarse, distinct, gray mottles when moist; single grain; slightly hard when dry, loose when moist; strongly calcareous; clear, wavy boundary.

C3—40 to 54 inches, light-gray (5Y 7/1) sand, light olive gray (5Y 6/2) when moist; a few, fine, faint, brown mottles; single grain; slightly hard when dry, loose when moist; calcareous; contains a few pebbles; 20 percent of horizon is shale sand.

IIC4—54 to 66 inches, light brownish-gray (2.5Y 6/2) gravelly coarse sand, dark grayish brown (2.5Y 4/2) when moist; a few, fine, faint, brown mottles; single grain; soft when dry, loose when moist; calcareous.

The A horizon ranges from 14 to 24 inches in thickness and from fine sandy loam or sandy loam to loam in texture. The C1ca horizon ranges from sandy loam or fine sandy loam to loamy fine sand in texture and from gray through grayish brown to dark grayish brown in color. In most places the C horizons below the C1ca horizon consist of sand that ranges from fine to coarse, but they contain a thin layer of finer textured material in a few places. The content of gravel in these C horizons ranges from 0 to 20 percent. In a few places, the profile contains a small amount of soluble salts and gypsum.

The Fossum soils are more poorly drained than the Ulen and Gilby soils. They are similar to the Borup soils in drainage, but they are coarser textured than those soils. The Fossum soils have a thinner C1ca horizon than the Arveson soils.

In Walsh County the Fossum soils were mapped only in complexes with the Arveson soils.

Gardena Series

The Gardena series consists of soils that are deep and moderately well drained. These soils have formed in medium-textured glacial lake sediment and in post glacial alluvium. They have a high proportion of silt and very fine sand. The native vegetation was tall prairie grasses.

In a typical profile, the surface layer is dark-gray silt loam about 11 inches thick. The subsoil is about 16 inches thick. It consists of very dark grayish-brown silt loam in the upper part, of dark grayish-brown silt loam in the middle part, and of grayish-brown, strongly calcareous very fine sandy loam in the lower part. The substratum is pale-olive, strongly calcareous very fine sandy loam that is mottled in the lower part and extends to a depth of 60 inches or more.

These soils have moderate permeability and high available water capacity. The water table is very deep.

Typical profile of Gardena silt loam, nearly level, in a cultivated field (300 feet east and 370 feet south of the northwest corner of the SW¼ of sec. 9, T. 157 N., R. 52 W.):

Ap—0 to 5 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; cloddy, breaking to moderate, medium and fine, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A1—5 to 11 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; moderate, very fine, crumb structure; slightly hard when dry, friable when moist, sticky and plastic when wet; clear boundary.

B21—11 to 16 inches, very dark grayish-brown (10YR 3/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, medium and coarse, prismatic structure breaking to moderate, fine, subangular blocky structure; slightly hard when dry, firm when moist, sticky and plastic when wet; patches of clay films on the vertical surfaces of peds; clear, wavy boundary.

B22—16 to 20 inches, dark grayish-brown (2.5Y 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, prismatic structure; slightly hard when dry, friable when moist; gradual boundary.

B3ca—20 to 27 inches, grayish-brown (2.5Y 5/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, prismatic structure breaking to moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist; strongly calcareous; clear boundary.

C1ca—27 to 43 inches, pale-olive (5Y 6/3) very fine sandy loam, light olive brown (2.5Y 5/4) when moist; weak, fine, prismatic structure breaking to weak, thin, platy structure; soft when dry, very friable when moist; contains many fine root channels; strongly calcareous and contains a few nodules of segregated lime; clear boundary.

C2ca—43 to 60 inches, pale-olive (5Y 6/3) very fine sandy loam, light olive brown (2.5Y 5/4) when moist; many, fine, distinct, olive-yellow and gray mottles; massive; soft when dry, friable when moist; strongly calcareous.

The A horizon ranges from silt loam to very fine sandy loam in texture, and it is very dark gray in places. The B horizon ranges from loam or silt loam to very fine sandy loam in texture and from very dark grayish brown to grayish brown in color. In many places the B horizon has patchy clay films or stains of organic matter on the outer surfaces of the peds. The C horizon ranges from fine sandy loam or very fine sandy loam to loam or silt loam and from pale olive to light olive gray or light gray. It contains few to many yellow and gray mottles. In a few places where these soils are on levees along streams, the profile contains the surface layer of a buried soil.

Unlike the Glyndon and Zell soils, the Gardena soils have a B horizon, and in addition, they are deeper over the layer that contains a large amount of lime than are the Glyndon and Zell soils. The Gardena soils have less clay throughout their profile than the Overly soils, but they contain more clay than the Embden soils. The Gardena soils are better drained than the Borup and Perella soils, and they are not in shallow depressions like those soils. They have formed in a thicker deposit of lake sediment than the Lankin soils.

Gardena silt loam, nearly level (0 to 3 percent slopes) (GaA).—This soil is on lake plains and on levees along streams that have cut into the lake plain. In most places the levees are less than one-fourth mile wide. Their surface

is smooth, and the side slopes extend back from the channel of the stream. The profile of this soil is the one described as representative of the series. In many places, however, where this soil is on levees along streams, the substratum contains a very dark colored layer that is the surface layer of a buried soil.

This soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. Soil blowing is a moderate hazard in the cultivated areas. (Capability unit IIe-5; windbreak site 1)

Gardena silt loam, gently sloping (3 to 5 percent slopes) (GaB).—This soil is on short side slopes bordering streams and small coulees that dissect the lake plain. Its profile is similar to the one described as representative of the series, except that the surface layer is thinner and lighter colored as the result of erosion.

This soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. Soil blowing and water erosion are moderate hazards. (Capability unit IIe-5; windbreak site 1)

Gilby Series

The Gilby series consists of deep, calcareous soils that are somewhat poorly drained and poorly drained. These soils have formed in loamy lacustrine sediment that is underlain by loamy glacial till. They are on a glacial lake plain that is nearly level in some places and that contains shallow depressions in others. These slight differences in elevation, caused by the depressions, result in differences in drainage. Adjacent to these soils are several lake beach lines that have formed low ridges. The native vegetation was mainly tall prairie grasses, but it included medium grasses in the stony areas.

In a typical profile, the surface layer is about 10 inches thick and consists of calcareous loam that is very dark in the upper part and is dark gray in the lower part. Just beneath the surface layer is a layer that is about 14 inches thick and that contains a large amount of lime. This layer is light-gray, very strongly calcareous loam in the upper part and is pale-yellow, strongly calcareous loam in the lower part. The lower part has formed in glacial till in some places. The next layer is pale-yellow, mottled, strongly calcareous very fine sandy loam that is about 9 inches thick. It is underlain by mixed light olive-brown, olive-gray, and light brownish-gray, mottled, calcareous clay loam glacial till that extents to a depth of 60 inches or more.

During wet periods, these soils have a water table within 1 to 4 feet of the soil surface. Permeability is moderate in the layers that formed in lacustrine sediment, and it is moderately slow in the glacial till substratum. The available water capacity is high.

Typical profile of Gilby loam in a cultivated field (1,150 feet north and 250 feet east of the southwest corner of sec. 12, T. 156 N., R. 55 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; weak, fine, subangular blocky structure; friable when moist; many roots and fine pores; calcareous; abrupt, smooth boundary.

A12—6 to 10 inches, dark gray (10YR 4/1) loam, black (10YR 2/1) when moist; a few, fine, distinct, very dark gray mottles; moderate, medium, subangular blocky structure; friable when moist; calcareous; clear, smooth boundary.

C1gca—10 to 18 inches, light-gray (2.5Y 7/1) loam, gray (2.5Y 5/1) when moist; very weak, medium, prismatic structure breaking to medium and fine, subangular blocky structure; friable when moist; very strongly calcareous; clear, wavy boundary.

C2gca—18 to 24 inches, pale-yellow (2.5Y 7/3) light loam, olive (5Y 5/3) when moist; few, medium, distinct, yellowish-brown mottles; weak, coarse, subangular blocky structure; friable when moist; strongly calcareous; gradual, wavy boundary.

C3g—24 to 33 inches, pale-yellow (2.5Y 7/3) very fine sandy loam, light olive brown (2.5Y 5/3) when moist; few, fine, faint, light brownish-gray mottles and distinct, yellowish-brown mottles; massive; friable when moist; strongly calcareous; contains a few pebbles; abrupt, wavy boundary.

IIC4—33 to 60 inches, mixed light olive-brown (2.5Y 5/4), olive-gray (5Y 4/2), and light brownish-gray (2.5Y 6/2, moist) clay loam glacial till; many, medium, prominent, brown mottles; massive; firm when moist; calcareous; pebbles and stones distributed at random throughout the horizon; contains some pebbles of broken shale and crystals of gypsum.

The A horizon ranges from loam or silt loam to very fine sandy loam in texture and from 10 to 16 inches in thickness. Thickness of the Cgca horizon ranges from 12 to 24 inches, and thickness of the lacustrine sediment over glacial till ranges from 20 to 40 inches. The number of cobblestones and other stones on the surface and in the soil profile varies widely.

The Gilby soils have a less permeable glacial till substratum than the Glyndon soils. In contrast to the Lankin soils, they have a limy A horizon and lack a B horizon. The Gilby soils have a coarser textured A horizon than the Bearden and Colvin soils. They differ from the Hamerly soils in having an A horizon and an upper Cca horizon that formed in lake sediment.

Gilby loam (Gb).—This soil occupies areas between ridgelike, gravelly and sandy glacial lake beaches that are north-south oriented. It has the profile described as representative of the series.

Included with this soil in mapping were small areas of Gilby stony loam and areas of Gilby loam, wet, and of Tonka and Parnell soils in depressions that range from ½ acre to 2½ acres in size. Water is ponded in these depressions during the growing season unless artificial drainage is provided. Other inclusions consist of areas of Lankin loam that are so intermingled with the Gilby soils that separation was not practical. The Lankin soil makes up from 10 to 24 percent of some areas mapped as Gilby loam.

This Gilby soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county. The main limitations to its use for crops are the moderate to high susceptibility to soil blowing, and wetness caused by the water that ponds in the many depressions in spring. (Capability unit IIe-4L; windbreak site 1)

Gilby loam, wet (Ge).—This soil is in shallow depressions that are adjacent and lie parallel to sandy glacial lake beaches. It is wet as a result of the high water table and the water that ponds on the surface during the early part of the growing season. Surface drainage is poor because of the concave topography and the runoff that is restricted by the beach ridges. The profile of this soil is similar to the one described as typical of the series, except that olive colors and mottling are nearer the surface.

Included with this soil in mapping were areas of Gilby loam and of Tonka silt loam; numerous areas of Gilby soils that are moderately saline near the surface; and small stony areas that are impractical to cultivate because of the stones. Gilby loam makes up from 10 to 51 percent of the acreage in this mapping unit. The Tonka soil, which is in

the center of many of the depressions and is more poorly drained than typical for the Gilby soils, makes up about 5 percent of the acreage in the mapping unit.

This Gilby soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitations to its use for crops are poor drainage and the moderate to high susceptibility to soil blowing where this soil is cultivated. (Capability unit IIw–4L; windbreak site 2)

Gilby stony loam (0 to 3 percent slopes) (Gh).—This soil is on interbeach plains that contain small, shallow depressions. Runoff is trapped in the depressions after heavy rains and after periods of snowmelt. The profile is similar to the one described as representative of the series, except that from 3 to 15 percent of the surface layer consists of stones and boulders that make cultivation impractical.

Included with this soil in mapping were small areas of Lankin stony loam.

The many stones and boulders limit the use of this Gilby soil for crops. All or nearly all of the acreage is in native hay and pasture. (Capability unit VIs-Si; windbreak site 10)

Glyndon Series

The Glyndon series consists of deep, calcareous soils that are moderately well drained and somewhat poorly drained. These soils have formed in lacustrine sediment on the lake plain and on levees along streams. The native vegetation was mainly tall prairie grasses, but the vegetation under which the moderately saline Glyndon soil formed included salt-tolerant grasses.

In a typical profile, the surface layer is very dark gray, slightly calcareous silt loam about 8 inches thick. Just beneath the surface layer is a layer of gray silt loam that is about 20 inches thick and contains a large amount of lime. This layer is very strongly calcareous in the upper part and is strongly calcareous in the lower part. The next layer consists of stratified, light yellowish-brown and light olive-brown very fine sandy loam that is mottled with gray and extends to a depth of 55 inches or more.

Permeability is moderate, and the available water capacity is high. A seasonal high water table rises to within 2 to 5 feet of the soil surface during wet periods.

Typical profile of Glyndon silt loam, level, in a cultivated field (1,300 feet north and 180 feet east of the northwest corner of sec. 9, T. 158 N., R. 52 W.) :

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous and contains a few small spots where lime has accumulated; abrupt, smooth boundary.

C1ca—8 to 14 inches, gray (5Y 5/1) silt loam, dark gray (5Y 4/1) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; very strongly calcareous; clear, wavy boundary.

C2ca—14 to 28 inches, gray (2.5Y 5/1) silt loam, very dark gray (2.5Y 3/1) when moist; moderate, medium, subangular blocky structure; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; common fine pores; clear, wavy boundary.

C3—28 to 38 inches, light yellowish-brown (2.5Y 6/4) very fine sandy loam, olive brown (2.5Y 4/4) when moist; a few, fine, faint, gray mottles; massive, crushing to single grain; soft when dry, very friable when moist, nonsticky and nonplastic when wet; noncalcareous; clear, wavy boundary.

C4—38 to 55 inches, light olive-brown (2.5Y 5/4) very fine sandy loam, olive brown (2.5Y 4/4) when moist; common, medium, faint, gray mottles; massive, crushing to single grain; hard when dry, friable when moist, nonsticky and nonplastic when wet; noncalcareous.

The A horizon ranges from dark gray or very dark gray to very dark brown in color and from 6 to 16 inches in thickness. It is dominantly silt loam, but it is very fine sandy loam in places. Thickness of the Cca horizon ranges from 8 to 22 inches. The C3 and C4 horizons are dominantly very fine sandy loam, but in places they contain thin layers that range from fine sandy loam to silty clay. Where these soils are on levees along streams, the profile commonly contains a buried A horizon. In places the entire profile is nonsaline, but salinity ranges to moderate in some areas.

The Glyndon soils have less clay throughout their profile than the Bearden and Colvin soils. They are less well drained than the Gardena soils, and they lack the B horizon that is typical of the Gardena soils. The Glyndon soils are better drained than the Borup soils with which they are associated.

Glyndon silt loam, level (0 to 3 percent slopes) (GlA).—This soil has formed in lacustrine sediment in areas where the difference in elevation between the highest and the lowest points on the landscape is less than 18 inches. The profile is the one described as representative of the series.

Included with this soil in mapping were areas of poorly drained Borup silt loam and of Perella silt loam in depressions. Together these two included soils make up from 15 to 25 percent of the acreage in this mapping unit.

This Glyndon soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county. It is mainly limited in use for crops by its moderate to high susceptibility to soil blowing. During wet periods, however, slow surface drainage also interferes with field operations. Drainage has been improved in many areas by installing field drains. (Capability unit IIe–4L; windbreak site 1)

Glyndon silt loam, gently sloping (3 to 5 percent slopes) (GlB).—This soil is on low glacial lake beaches and on the side slopes of natural drainageways that cross the glacial lake plain. It has formed in lacustrine sediment.

This soil is suited to the commonly grown field crops, hay crops, and pasture plants. The major limitations to its use for crops are its susceptibility to soil blowing and water erosion. Water erosion is difficult to control on the steeper and longer slopes, and on the side slopes of drainageways. (Capability unit IIe–4L; windbreak site 1)

Glyndon silt loam, moderately saline (0 to 3 percent slopes) (Gm).—This soil is on a part of the glacial lake plain where there are many low ridges and shallow depressions. The difference in elevation between the highest and the lowest points on the landscape is generally less than 2 feet. The profile of this soil is similar to the one described as representative of the series, except that the soil material is moderately saline. Numerous crystals of salt are scattered throughout the soil profile.

Included with this soil in mapping were areas of a nonsaline Glyndon silt loam and of a Borup silt loam. The nonsaline Glyndon soil makes up from 10 to 15 percent of the acreage in this mapping unit, and the Borup soil makes up from 0 to 5 percent.

The chief limitations to use of this moderately saline Glyndon soil for crops are the somewhat restricted drainage, moderate salinity, and moderate to high susceptibility

to soil blowing. Most of the acreage is cultivated, but all the crops are adversely affected by the salts in the root zone. (Capability unit IIIws-4; windbreak site 9)

Grano Series

The Grano series consists of deep, poorly drained and very poorly drained soils that have formed in lacustrine sediment. These soils are nearly level and are on a part of the glacial lake plain characterized by low ridges and by intervening depressions. Differences in elevation between the highest and the lowest points on the landscape are slight. The native vegetation was mainly tall prairie grasses and wetland grasses.

In a typical profile, the surface layer is about 12 inches thick and consists of black, slightly calcareous silty clay in the upper part and of dark-gray, strongly calcareous silty clay in the lower part. Just beneath the surface layer is a layer of mottled silty clay that is about 24 inches thick and contains a large amount of lime. This layer is light-gray, very strongly calcareous silty clay in the upper part and is light olive-gray, strongly calcareous silty clay in the lower part. The next layer is light olive-gray, mottled silty clay about 14 inches thick. This layer is underlain by light-gray, mottled silty clay that extends to a depth of 60 inches or more.

Permeability is moderately slow in the surface layer and in the layer that contains a large amount of lime, and it is slow below these layers. The available water capacity is high. A seasonal high water table is at the surface or is within 3 feet of the surface during wet periods.

Typical profile of a Grano silty clay in a cultivated field (0.3 mile east and 135 feet south of the northwest corner of sec. 29, T. 158 N., R. 51 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay, black (10YR 2/1) when moist; cloddy, breaking to strong, very fine, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; slightly calcareous; abrupt, smooth boundary.

A1ca—7 to 12 inches, dark-gray (5Y 4/1) silty clay, very dark gray (5Y 3/1) when moist; a few, fine, faint, brown mottles; strong, very fine, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; strongly calcareous; clear, irregular boundary; tongues of material from this horizon extend downward to a depth of 24 inches.

C1gca—12 to 24 inches, light-gray (5Y 7/2) silty clay, olive gray (5Y 5/2) when moist; many, fine, distinct, brown and gray mottles; moderate, fine and very fine, angular blocky structure; slightly hard when dry, firm when moist, very sticky and very plastic when wet; very strongly calcareous; gradual, wavy boundary.

C2gca—24 to 36 inches, light olive-gray (5Y 6/2) silty clay, olive (5Y 4/3) when moist; many, fine, distinct, dark-gray and yellowish-brown mottles; moderate, fine, angular blocky structure; slightly hard when dry, firm when moist, very sticky and very plastic when wet; strongly calcareous; gradual boundary.

C3g—36 to 50 inches, light olive-gray (5Y 6/2) silty clay, olive (5Y 4/3) when moist; many, medium, distinct, gray mottles and many, fine, distinct, light olive-brown mottles; strong, fine, angular blocky structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; slightly calcareous; contains a few nodules of manganese and lime; gradual boundary.

C4g—50 to 60 inches, light-gray (5Y 7/2) silty clay, olive (5Y 5/3) and gray (5Y 5/1) when moist; many, fine, distinct, yellowish-brown mottles; strong, very fine, angular blocky structure; very hard when dry, very firm when moist, very sticky and very plastic when wet; slightly calcareous.

The A horizon is slightly calcareous to strongly calcareous, and it ranges from 6 to 16 inches in thickness. Where drainage is poorest, some areas of this soil are more clayey than normal for Grano soils in this county. The Cg horizons consist of varved, clayey lacustrine material that has been changed but little by weathering or by the other processes of soil development. Depth to this varved clayey material ranges from 3 to 5 feet.

The Grano soils are more poorly drained than the Hegne soils, and they are more calcareous than the Fargo soils. The Grano soils are finer textured than the Colvin soils.

Grano silty clay, very wet (0 to 1 percent slopes) (Gr).—This soil is in depressions where the water table is high, and where water from runoff ponds on the surface. The profile is similar to the one described as representative of the series, except that the layer in which lime has accumulated is at a greater depth and mottling occurs higher in the profile.

Because of its very poor drainage, this soil has remained in native vegetation. (Capability unit Vw-WL; drained areas of this soil are in windbreak site 2, and undrained areas are in windbreak site 10)

Grano-Hegne silty clays (0 to 1 percent slopes) (Gs).—About 65 percent of this mapping unit is Grano silty clay, and about 35 percent is Hegne silty clay. These soils are on glacial lake plains that are characterized by low ridges and by depressions that are between the ridges. Differences in elevation between the highest and the lowest points on the landscape are slight. The Grano soil is in the depressions, and the Hegne soil is on the low ridges. The Grano soil has the profile described as representative of the Grano series. The Hegne soil has a profile similar to the one described as typical of the Hegne series, except that the surface layer is thinner.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitation to use of these soils for crops is their poor drainage, but the soils are also moderately to highly susceptible to soil blowing if they are cultivated. Where outlets are available, drainage is improved by installing field drains. (Capability unit IIwe-4; the Grano soil is in windbreak site 2, and the Hegne soil is in windbreak site 1)

Hamar Series

The Hamar series consists of deep, somewhat poorly drained and poorly drained soils that have formed in depressions on glacial outwash plains. The native vegetation was tall prairie grasses.

In a typical profile, the surface layer is very dark grayish-brown loamy sand about 16 inches thick. The subsoil is about 12 inches thick, and it consists of loamy sand that is dark grayish brown in the upper part and is grayish brown in the lower part. The substratum is mottled medium sand that is pale yellow in the upper part and is light olive gray in the lower part. The substratum extends to a depth of 60 inches or more.

Permeability is moderate or moderately rapid throughout the profile. The available water capacity is moderate in the surface layer, and it is low in the material below the surface layer. The average available water capacity is low. A seasonal high water table rises to the surface or is within 3 feet of the surface during wet periods.

Typical profile of a Hamar loamy sand (80 feet west and 80 feet south of the northeast corner of the NW¼ of sec. 20, T. 157 N., R. 55 W.):

A11—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy sand, black (10YR 2/1) when moist; weak, medium, subangular blocky structure; very friable when moist; abrupt boundary.
A12—8 to 16 inches, very dark grayish-brown (10YR 3/2) loamy sand, black (10YR 2/1) when moist; weak, coarse, subangular blocky structure breaking easily to weak, fine, crumb structure; very friable when moist; clear boundary.
B2—16 to 22 inches, dark grayish-brown (10YR 4/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; single grain; loose when dry or moist; clear boundary.
B3—22 to 28 inches, grayish-brown (2.5Y 5/2) loamy sand, very dark grayish brown (2.5Y 3/2) when moist; single grain; loose when dry or moist; contains a few nodules of manganese; clear boundary.
C1—28 to 36 inches, pale-yellow (2.5Y 7/4) medium sand, light olive brown (2.5Y 5/4) when moist; common, medium, distinct, dark yellowish-brown mottles; common, medium, distinct, yellowish-brown mottles when moist; single grain; loose when dry or moist; contains common nodules of manganese.
C2g—36 to 60 inches, light olive-gray (5Y 6/2) medium sand, olive gray (5Y 5/2) when moist; common, coarse, prominent, black mottles; single grain; contains a few nodules of manganese.

Texture of the A and B horizons ranges from loamy sand to sandy loam. In most places the A and B horizons are noncalcareous throughout, but in places the profile includes a layer that contains a large amount of lime. This layer is below the B horizon.

The Hamar soils are more poorly drained than the Hecla soils. Unlike the Ulen soils, they have a B horizon.

Hamar and Ulen loamy sands (0 to 3 percent slopes) (Ha).—Soils of this mapping unit are on glacial outwash plains. They occur in such complex patterns that it was impractical to map them separately. About 65 percent of the acreage is Hamar loamy sand, and 35 percent is Ulen loamy sand. The Hamar soil is in concave areas, and the Ulen soil occupies convex slopes at a slightly higher elevation than the Hamar soil. The Hamar soil has the profile described as representative of the Hamar series. The Ulen soil has a profile similar to the one described as representative of the Ulen series, except that the surface layer is thicker and is loamy sand.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitations to use of these soils for crops are their very high susceptibility to soil blowing and their restricted drainage. (Capability unit IVe–2; the Hamar soil is in windbreak site 2, and the Ulen soil is in windbreak site 1)

Hamar and Ulen sandy loams (0 to 3 percent slopes) (Hd).—About 55 percent of the acreage of this mapping unit is Hamar sandy loam, and about 45 percent is Ulen sandy loam. These soils are on glacial outwash plains. The Hamar soil is in depressions, and it is more poorly drained than the Ulen. The Ulen soil is on convex slopes at a slightly higher elevation than the Hamar soil. The profiles of these soils are similar to the ones described as representative of their respective series, except that the Hamar soil has a surface layer of sandy loam.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitations to use of these soils for crops are their restricted drainage and their very high susceptibility to soil blowing. (Capability unit IIIwe–3; the Hamar soil is in windbreak site 2, and the Ulen soil is in windbreak site 1)

Hamerly Series

The Hamerly series consists of deep, calcareous, moderately well drained and somewhat poorly drained soils that have formed in calcareous loam glacial till. These soils occupy short slopes on glacial till plains where potholes are a part of the landscape. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is about 14 inches thick and consists of very dark gray, slightly calcareous loam in the upper part and of grayish-brown, strongly calcareous heavy loam in the lower part. Just beneath the surface layer is a layer of pale-yellow clay loam that is about 17 inches thick and contains a large amount of lime. This layer is very strongly calcareous in the upper part and is strongly calcareous in the lower part. The next layer is pale-olive, calcareous clay loam glacial till that extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer and in the layer that contains a large amount of lime, and it is slow below those layers. The available water capacity is high. A seasonal high water table rises to within 2 to 5 feet of the soil surface during wet periods.

Typical profile of a Hamerly loam in a cultivated field (390 feet east and 55 feet south of the northwest corner of sec. 4, T. 156 N., R. 58 W.):

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; cloddy, breaking to weak, very fine, crumb structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; slightly calcareous; abrupt, smooth boundary.
A1ca—7 to 14 inches, grayish-brown (10YR 5/2) heavy loam, black (10YR 2/1) when moist; weak, very coarse, angular blocky structure breaking to moderate, medium and fine, angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; clear, wavy boundary.
C1ca—14 to 25 inches, pale-yellow (2.5Y 8/4) clay loam, light olive brown (2.5Y 5/4) when moist; weak, coarse, prismatic structure breaking to moderate, fine and very fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; about 2 percent of horizon is shale pebbles larger than 2 millimeters in diameter; clear, wavy boundary.
C2ca—25 to 31 inches, pale-yellow (5Y 7/3) clay loam, olive (5Y 5/4) when moist; moderate, medium, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; clear, wavy boundary.
C3cs—31 to 46 inches, pale-olive (5Y 6/3) clay loam glacial till, olive (5Y 5/4) when moist; moderate, medium, subangular blocky structure breaking to weak, very fine, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; calcareous; common gypsum crystals; gradual, wavy boundary.
C4—46 to 60 inches, pale-olive (5Y 6/3) light clay loam, olive (5Y 5/3) when moist; common, medium, distinct, gray and brown mottles; weak, very fine, angular blocky structure; hard when dry, firm when moist, sticky and very plastic when wet; calcareous; about 5 percent of horizon is shale pebbles larger than 2 millimeters in diameter.

The A horizon is clay loam in some places, and it ranges from black or very dark gray to grayish brown in color and

from 7 to 14 inches in thickness. Where the A horizon is grayish brown, it is more calcareous than where it has a darker color. Where these soils are on convex slopes or on side slopes adjacent to potholes, they are moderately eroded and the A horizon is thinner than in other places. Below the layer that contains a large amount of lime, the C horizons range from pale olive to light olive brown in color and from clay loam to loam in texture. In places the profile lacks a layer that is high in content of gypsum, but the layers below the Cca horizons generally contain some gypsum and are mottled to some extent. From 1 to 10 percent of the entire soil profile consists of pebbles, cobblestones, and other stones.

The Hamerly soils have a more calcareous A horizon than the Barnes, Svea, Cresbard, and Cavour soils, and they lack the B horizon that is typical in the profile of those soils. They are better drained than the Vallers soils.

Hamerly-Cresbard loams (0 to 3 percent slopes) (He).—Soils of this mapping unit are in swales, in areas along intermittent drainageways, or adjacent to potholes on the glacial till plain. About 55 percent of the acreage is Hamerly loam, 35 percent is Cresbard loam, and 10 percent is Vallers and other soils. The soils occur in such complex patterns that it was impractical to map them separately.

Included with these soils in mapping were many small areas of Vallers soils, and a few small areas of Cavour, Svea, and Tonka soils.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. The chief limitation to use of these soils for crops is the claypan that restricts the growth of roots in the subsoil of the Cresbard soil. In addition, the Hamerly soil is moderately to highly susceptible to soil blowing. (Capability unit IIIs–P; the Hamerly soil is in windbreak site 1, and the Cresbard soil is in windbreak site 4)

Hamerly-Svea loams, nearly level (0 to 3 percent slopes) (HgA).—About 50 percent of this mapping unit is Hamerly loam, 35 percent is Svea loam, and 15 percent is other soils. These soils are on uplands underlain by glacial till. The slopes are short, and most of them have a gradient of about 2 percent. Difference in elevation between the highest and the lowest places on the landscape is only 3 to 9 feet. The areas contain numerous potholes in which water frequently ponds. The Hamerly soil is on slightly convex rises and knolls, and it also is on side slopes adjacent to depressions. The Svea soil is in concave areas. The Hamerly soil has the profile described as representative for the Hamerly series.

Included with these soils in mapping were small areas of Parnell, Tonka, Cresbard, and Cavour soils, and small areas of poorly drained Vallers soils. The Parnell and Tonka soils have water ponded on their surface during wet periods. The Cresbard and Cavour soils contain a claypan.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. The chief limitation to use of these soils for crops is their moderate to high susceptibility to soil blowing. In addition, the many depressions in some areas interfere with fieldwork. In some places where outlets are available, ditches are used to drain water from the depressions. (Capability unit IIe–4L; windbreak site 1)

Hamerly-Svea loams, gently undulating (3 to 5 percent slopes) (HgB).—Soils of this mapping unit are on glacial till uplands. The areas contain numerous small potholes in which water is frequently ponded. Slopes are short, and the difference in elevation between the highest and the lowest places on the landscape is only 10 to 15 feet. About 45 percent of this mapping unit is Hamerly loam, 35 percent is Svea loam, and 20 percent is other soils. The Hamerly soil is on convex ridges and knolls, and the Svea soil is in concave lower areas.

Included with these soils in mapping were small areas of poorly drained Vallers and well-drained Barnes soils. Also included were small areas of Parnell, Tonka, Cresbard, and Cavour soils. Water frequently ponds on the surface of the Parnell and Tonka soils, and a claypan restricts the growth of roots in the subsoil of the Cresbard and Cavour soils.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. The chief limitation to use of these soils for crops is their moderate to high susceptibility to soil blowing. Water erosion is also a hazard on the steeper, longer slopes, and some areas are eroded, especially where these soils are on knolls. In addition, the many depressions interfere with fieldwork in some places. In some areas where outlets are available, ditches have been installed to drain water from the depressions. (Capability unit IIe–4L; windbreak site 1)

Hattie Series

The Hattie series consists of deep, calcareous soils that are well drained and moderately well drained. These soils have formed in calcareous lacustrine sediment that is dominantly fine textured. They occupy side slopes along streams, the sides of valleys that dissect the glacial lake plain, and side slopes of the basin of Lake Ardoch and the basins of other salt lakes. The native vegetation consists of medium and tall prairie grasses and scattered shrubs.

In a typical profile, the surface layer is about 5 inches thick and is very dark gray silty clay. Tongues of material from the surface layer extend downward into the layer below. The layer just below the surface layer is about 15 inches thick, it contains a large amount of lime and consists of light brownish-gray, strongly calcareous silky clay. The next layer is stratified, calcareous silty clay and clay that contain thin layers of silt. It is grayish brown in the upper part and is light brownish gray in the lower part and it extends to a depth of 60 inches or more.

In the surface layer and in the layer that contains a large amount of lime, permeability is moderately slow and the available water capacity is very high. In the layers below the one that contains a large amount of lime, permeability is slow and the available water capacity is high. The average available water capacity is high. These soils have a very deep water table.

Typical profile of Hattie silty clay, lacustrine, in a cultivated field (0.3 mile west and 100 feet south of the northeast corner of sec. 1, T. 157 N., R. 52 W.):

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; cloddy, breaking to moderate, fine, granular structure; hard when dry, firm when moist, very sticky and very plastic when wet; slightly calcareous; abrupt, wavy boundary.

C1ca—5 to 20 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) when moist; few, fine,

faint, brown and gray mottles; moderate, very fine, angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; strongly calcareous; contains a few fine nodules of lime; abrupt, smooth boundary.

C2—20 to 36 inches, grayish-brown (2.5Y 5/2), stratified silty clay and silt, very dark grayish brown (2.5Y 3/2) when moist; common, medium, prominent, brown and gray mottles; strong, fine and very fine, angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; calcareous; contains common nodules of lime 2 to 10 millimeters in diameter; clear boundary.

C3gcs—36 to 60 inches, light brownish-gray (2.5Y 6/2), stratified clay and silt, dark grayish brown (2.5Y 4/2) when moist; common, fine, prominent, brown and gray mottles; strong, medium, angular blocky structure; hard when dry, very firm when moist, very sticky and very plastic when wet; calcareous; contains a few nodules of lime and segregated gypsum in nodules and masses.

The A horizon ranges from 4 to 12 inches in thickness. It is thickest where these soils are in concave areas at the base of slopes. The A horizon is noncalcareous in areas under native grass, but it is slightly calcareous or moderately calcareous in areas that are cultivated. Depth to stratified silty clay and clay ranges from 18 to 24 inches.

The Hattie soils are steeper than the Bearden and Hegne soils, and they lack the seasonal high water table that is typical in areas of those soils.

Hattie silty clay, lacustrine (6 to 12 percent slopes) (Hh).—This is the only soil of the Hattie series mapped in Walsh County. It has formed in fine-textured lacustrine material on side slopes along the major streams that dissect the lake plain. It is also on side slopes of the Lake Ardoch basin and the basins of other salt lakes. Some areas are eroded to the extent that material from the layer that contains a large amount of lime is mixed with the remaining surface layer each time the soil is plowed.

Included with this soil in mapping were areas of Bearden silty clay loam and of Hegne silty clay that are adjacent to this soil on the upper parts of slopes. These included soils are deeper over a stratified, clayey substratum than typical for Hattie soils.

The chief limitation to use of this Hattie soil for crops is its moderate to high susceptibility to soil blowing and water erosion. About 60 percent of the acreage is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and that acreage is cultivated. Areas of this soil adjacent to Lake Ardoch are in native grass. (Capability unit IVe-4; windbreak site 8)

Hecla Series

The Hecla series consists of deep, moderately well drained soils that are coarse textured and moderately coarse textured. These soils are on beach lines, in interbeach areas, and on glacial outwash plains, where wind has reworked the soil material in some places. The native vegetation was tall prairie grasses.

In a typical profile, the surface layer is about 32 inches thick and consists of loamy sand that is very dark gray in the upper part, very dark grayish brown in the middle part, and dark grayish brown in the lower part. Just below the surface layer is a layer of light yellowish-brown sand about 23 inches thick. Underlying this layer is mottled, pale-olive clay loam glacial till that extends to a depth of 60 inches or more.

These soils have moderately rapid permeability above the glacial till, but they have slow permeability in the till. The available water capacity is moderate to low. The water table is within 4 to 5 feet of the soil surface during wet periods.

Typical profile of Hecla loamy sand, nearly level (680 feet east and 170 feet south of the northwest corner of sec. 33, T. 155 N., R. 55 W.):

A11—0 to 17 inches, very dark gray (10YR 3/1) loamy sand, black (10YR 2/1) when moist; weak, fine, crumb structure; soft when dry, friable when moist; gradual boundary.

A12—17 to 24 inches, very dark grayish-brown (2.5Y 3/2) loamy sand, very dark brown (10YR 2/2) when moist; weak, fine, crumb structure; soft when dry, very friable when moist; gradual boundary.

A13—24 to 32 inches, dark grayish-brown (2.5Y 4/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; single grain; soft when dry, very friable when moist; clear boundary.

C1—32 to 55 inches, light yellowish-brown (2.5Y 6/4) sand, dark yellowish brown (10YR 4/4) when moist; single grain; soft when dry, loose when moist; contains a few pebbles.

IIC2—55 to 60 inches, pale-olive (5Y 6/3) clay loam glacial till, olive (5Y 4/3) when moist; common, medium, prominent, yellowish-brown (10YR 5/8) mottles; massive; firm when moist, sticky and plastic when wet; contains a few nodules of lime; very strongly calcareous.

The A horizon ranges from loamy sand to light sandy loam in texture. Where the texture is sandy loam, the A horizon is generally thinner than where it is coarser textured. In a few places, a weakly defined B horizon is immediately below the A horizon. Color of the C1 horizon ranges from light yellowish brown to grayish brown, and in some places the profile has distinct brownish and grayish mottles in the lower part of the C1 horizon. Texture of the C1 horizon is generally sand or loamy sand. It is coarse sand in a few places, however, and in some areas finer textured material is below a depth of 50 inches. The profile is normally noncalcareous throughout, but it is slightly calcareous in some places.

The Hecla soils are less well drained than the Maddock soils, and they have a thicker A horizon than the Maddock soils. They contain more sand than the Embden soils, and they lack the well-defined B horizon that is typical in the Embden profile. The Hecla soils lack a Cca horizon immediately below the A horizon that is typical of the Ulen and Arveson soils. They are better drained than the Arveson, Fossum, and Hamar soils.

Hecla loamy sand, nearly level (0 to 3 percent slopes) (HlA).—This soil is in interbeach areas and on glacial outwash plains. It has the profile described as representative of the series.

Included with this soil in mapping were small areas of Maddock loamy sand and areas of moderately eroded Hecla soils that have a thinner surface layer than typical for this soil.

This nearly level Hecla soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The chief limitations to use of this soil for crops are its very high susceptibility to soil blowing, and droughtiness as a result of the moderate to low available water capacity. Where soil blowing has been extensive, drifts of soil material are common along fence lines and along the boundaries of fields. (Capability unit IVe-2; windbreak site 1)

Hecla loamy sand, gently undulating (3 to 12 percent slopes) (HlB).—This soil is on beach lines, along terrace fronts, and in entrenched coulees. Its profile is similar to the one described as representative of the series. The sur-

face layer is thinner, however, although it is generally thicker on the lower parts of the slopes than on the upper parts.

Included with this soil in mapping were areas of moderately eroded Hecla soils, small areas of Maddock loamy sand, and small areas of Hamar and Fossum soils.

The chief limitations to use of this Hecla soil for crops are its very high susceptibility to soil blowing and its droughtiness as a result of the moderate to low available water capacity. Where this soil is cultivated, however, it is suited to the commonly grown field crops, hay crops, and pasture plants. (Capability unit IVe-2; windbreak site 1)

Hegne Series

The Hegne series consists of deep, poorly drained soils that contain a large amount of lime. These soils are on glacial lake plains, where they have formed in fine-textured lacustrine sediment. The native vegetation was mostly tall prairie grasses, but the saline Hegne soils have formed under mixed tall prairie grasses and salt-tolerant grasses. The strongly saline and alkali Hegne soils have formed under salt-tolerant grasses.

In a typical profile, the surface layer is about 14 inches thick and consists of very dark gray silty clay that is slightly calcareous in the upper part and is strongly calcareous in the lower part. Just beneath the surface layer is a layer, about 17 inches thick, that is strongly calcareous and contains a large amount of lime. This layer is gray silty clay loam in the upper part and is pale-yellow silty clay in the lower part. The next layer consists of calcareous, mottled lacustrine sediment that is light olive-gray clay in the upper part and is pale-yellow clay in the lower part. This layer extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer, and it is moderately slow or slow in the underlying layers. The available water capacity is very high. A seasonal high water table is within 3 to 5 feet of the surface during wet periods.

Typical profile of a Hegne silty clay in a cultivated field (250 feet north and 560 feet east of the southwest corner of the NW¼ of sec. 31, T. 157 N., R. 51 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; moderate, medium and very fine, subangular blocky structure; very hard when dry, firm when moist, sticky and very plastic when wet; slightly calcareous; abrupt, smooth boundary.

A1ca—6 to 14 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; moderate, medium and fine, subangular blocky structure; hard when dry, firm when moist, sticky and very plastic when wet; strongly calcareous; abrupt, irregular boundary; narrow tongues of soil material from this horizon extend downward to a depth of 25 inches.

C1ca—14 to 18 inches, gray (N 5/0) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; clear, broken boundary.

C2ca—18 to 31 inches, pale-yellow (5Y 7/3) silty clay, light olive brown (2.5Y 5/4) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist, sticky and very plastic when wet; strongly calcareous; gradual, wavy boundary.

C3—31 to 41 inches, light olive-gray (5Y 6/2) clay, light olive brown (2.5Y 5/4) when moist; a few, fine, faint, gray and brown mottles; strong, fine, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; calcareous; many fine root channels; abrupt, wavy boundary.

C4—41 to 60 inches, pale-yellow (5Y 7/3) clay, olive (5Y 4/3) when moist; a few, fine, prominent, brown (7.5YR 4/4) mottles; no developed structure, but contains horizontal strata of lacustrine clay 2 to 10 millimeters thick; very hard when dry, firm when moist, very sticky and very plastic when wet; slightly calcareous; a few gypsum crystals and nodules of manganese; a few fine root channels.

The A horizon ranges from 9 to 15 inches in thickness, and it is dark gray in places. In some small areas, the A horizon is clay or silty clay loam. The Cca horizons range from gray or pale yellow to light olive brown or dark grayish brown in color and from 10 to 21 inches in combined thickness. In a few places, the C horizon below the layer of limy material contains thin layers of silty clay loam. Salinity throughout the profile ranges from none to moderate.

The Hegne soils have more clay throughout their profile than the Bearden soils. They are better drained than the Grano soils, and they have a Cca horizon closer to the surface than that of the Fargo soils.

Hegne-Fargo silty clays, nearly level (0 to 3 percent slopes) (HmA).—About 55 percent of this mapping unit is Hegne silty clay, 35 percent is Fargo silty clay, and 10 percent is other soils. The soils are on a glacial lake plain where low ridges, nearly level areas, and shallow depressions form irregular patterns. The Hegne soil is on the ridges, and the Fargo soil is in the nearly level areas and in some depressions. The Hegne soil has the profile described as representative of the Hegne series.

Included with these soils in mapping were a few moderately saline areas and areas of Grano silty clay in small depressions. Also included were small areas of soils that are in depressions and that have a silt loam subsurface layer 2 to 13 inches thick, have a clay subsoil, and lack the high content of lime typical of the Hegne soils.

Soils of this mapping unit are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. The chief limitation to use of the soils for crops is their poor natural drainage, but the soils are also moderately to highly susceptible to soil blowing if they are cultivated. In some places where outlets are available, drainage has been improved by constructing field drains. (Capability unit IIwe-4; windbreak site 1)

Hegne-Fargo silty clays, gently sloping (3 to 5 percent slopes) (HmB).—About 60 percent of this mapping unit is Hegne silty clay, and 40 percent is Fargo silty clay. Profiles of these soils are similar to those described as representative of their respective series, except that the surface layer is thinner and lighter colored.

Soils of this mapping unit are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. The soils are moderately to highly susceptible to soil blowing, however, and water erosion is a hazard in some areas during spring runoff or during rainstorms of high intensity. (Capability unit IIe-4; windbreak site 1)

Hegne silty clay, saline (0 to 3 percent slopes) (Hn).—This soil is on glacial lake plains. It is mostly nearly level or very gently undulating. The profile is similar to the one described as representative of the series, except that it is moderately saline. When this soil is dry, salt crystals are visible throughout the surface layer. The severity of the salinity varies greatly within short distances. The highest lying areas of this soil are more strongly saline than those at lower elevations. Local relief differs by only a few inches.

Included with this soil in mapping were areas of Grano and Fargo soils in shallow depressions, and small areas of nonsaline Hegne silty clay. Also included were small areas of nonsaline soils that lack the high content of lime typical of Hegne soils and that have a surface layer of silty clay, a subsurface layer of silt loam that is 2 to 13 inches thick, and a subsoil of clay.

The chief limitations to use of this Hegne soil for crops are its salinity, poor natural drainage, and moderate to high susceptibility to soil blowing. Part of the acreage is used for cultivated crops, and part is in hay and pasture. The cultivated crops are adversely affected by the salts in this soil. The degree to which they are affected depends on the amount of moisture received during the growing season and on the salinity of the particular area. (Capability unit IIIws-4; windbreak site 9)

Hegne silty clay, strongly saline-alkali (0 to 1 percent slopes) (Hs).—This soil is on glacial lake plains associated with North Salt Lake. It is in an area where the water table is high much of the time. The profile is similar to the one described as representative of the series, except that it is strongly saline and alkali. Few crystals of salt are visible in the surface layer, but the exchangeable sodium content of the surface layer is as high as 15 to 20 percent in some places. When this soil is dry, flakes of organic matter that have come out of the soil as a dispersed gel are on the surface. Cultivated areas contain slickspots or gumbo spots where the surface soil is dispersed. In areas under grass, the plants in some areas are short and the stand is thin.

Included with this soil in mapping were small areas of Fargo silty clay in a few shallow depressions. Also included in these depressions were small areas of soils that are nonsaline, that lack the high content of lime typical of the Hegne soils, and that have a surface layer of silty clay, a subsurface layer of silt loam 2 to 13 inches thick, and a subsoil of clay.

The chief limitations to use of this Hegne soil for crops are its strong salinity and poor natural drainage. Nearly all of the acreage is in native grass or pasture. (Capability unit VIs-SS; windbreak site 10)

Kloten Series

The Kloten series consists of well-drained soils that have formed in shallow deposits of glacial till over shale. These soils are on the side slopes of river valleys. The native vegetation was short, medium, and tall prairie grasses.

In a typical profile, the surface layer is very dark gray loam about 5 inches thick. In wooded areas it is covered by a thin layer of leaf litter and plant residue. Just beneath the surface layer is a layer of gray clay loam glacial till about 8 inches thick. The till is underlain by gray, bedded shale that is partly weathered in the uppermost 17 inches. Figure 8 shows a road ditch where a profile of a Kloten soil is exposed.

Kloten soils have moderate permeability in the surface layer, moderately slow permeability between the surface layer and the underlying shale, and very slow permeability in the shale. They have high available water capacity above the shale and very low available water capacity in the shale. Because depth to shale is less than 20 inches, the total available water capacity is very low. The water table is very deep.

Typical profile of a Kloten loam (462 feet west and 660 feet north of the southeast corner of the SW¼ of sec. 11, T. 157 N., R. 57 W.):

O1—1 inch to 0, leaf litter and plant residue.

A1—0 to 5 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; weak, fine and medium, granular structure; loose when dry, very friable when moist, plastic and slightly sticky when wet; abrupt boundary.

C1—5 to 13 inches, gray (5Y 5/1) clay loam, very dark gray (5Y 3/1) when moist; moderate, fine and medium, granular structure; loose when dry, very friable when moist, sticky and very plastic when wet; abrupt boundary.

R1—13 to 30 inches, gray (5Y 5/1), partly weathered shale, dark olive gray (5Y 3/2) when moist; coated with strong brown (7.5YR 5/6); platy because of the horizontal cleavage of the shale.

R2—30 to 60 inches, very dark gray (5Y 3/1) shale, black (5Y 2/2) when moist; coated with strong brown (7.5YR 5/6); contains a few roots to a depth of 54 inches; a few pebble-sized nodules of lime are at depths between 44 and 47 inches.

Texture of the A horizon ranges from loam or shaly loam to clay loam. In places the C horizon is shaly loam. The content of shale in the A and C horizons is variable. Depth to shale bedrock ranges from 13 to 20 inches. The shale is gray or very dark gray.

The Kloten soils are shallower over bedrock than the Edgeley and Buse soils. Unlike the Coe soils, they lack deposits of shaly gravel in their substratum.

Kloten complex (9 to 30 percent slopes) (Kn).—This mapping unit is dominantly Kloten loam, but it also contains Buse and Edgeley soils, other soils, and outcrops of shale bedrock. About 40 percent of the mapping unit is Kloten loam, 20 percent is Buse loam, 10 percent is Edgeley loam, another 10 percent is other soils, and 20 percent is rock outcrops.

The Kloten soil is covered with trees, and it is on the sides and most of the upper slopes of valleys. The Buse soil is on the upper side slopes of valleys, where a thick mantle of glacial till overlies shale bedrock. The Edgeley soil occupies nearly level areas along the edges of the valleys. Most of the bare, exposed areas of weathered shale are on south-facing and west-facing slopes.

Included with these soils in mapping were areas on narrow valley bottoms that consist of weathered shale sloughed down from the upper slopes, of silty and clayey alluvial material, and of many glacial boulders. This material is moderately wet because of the high water table.

Soils of this mapping unit are used mainly for pasture. The chief limitation to their use for crops is droughtiness caused by the shallow root zone of the Kloten soil and by the rapid runoff on the moderately steep and steep slopes. (Capability unit VIs-Sw; windbreak site 10)

Lamoure Series

The Lamoure series consists of deep, poorly drained soils that have formed in loamy alluvium that is 40 inches or more thick. These soils are on bottom lands, on the flood plains of streams, and in intermittent drainageways. The native vegetation was wetland grasses and salt-tolerant grasses.

In a typical profile, the surface layer is dark-gray silty clay loam about 10 inches thick. Just below the surface layer is calcareous, stratified, loamy alluvial material that has brown mottles in most layers and extends to a depth

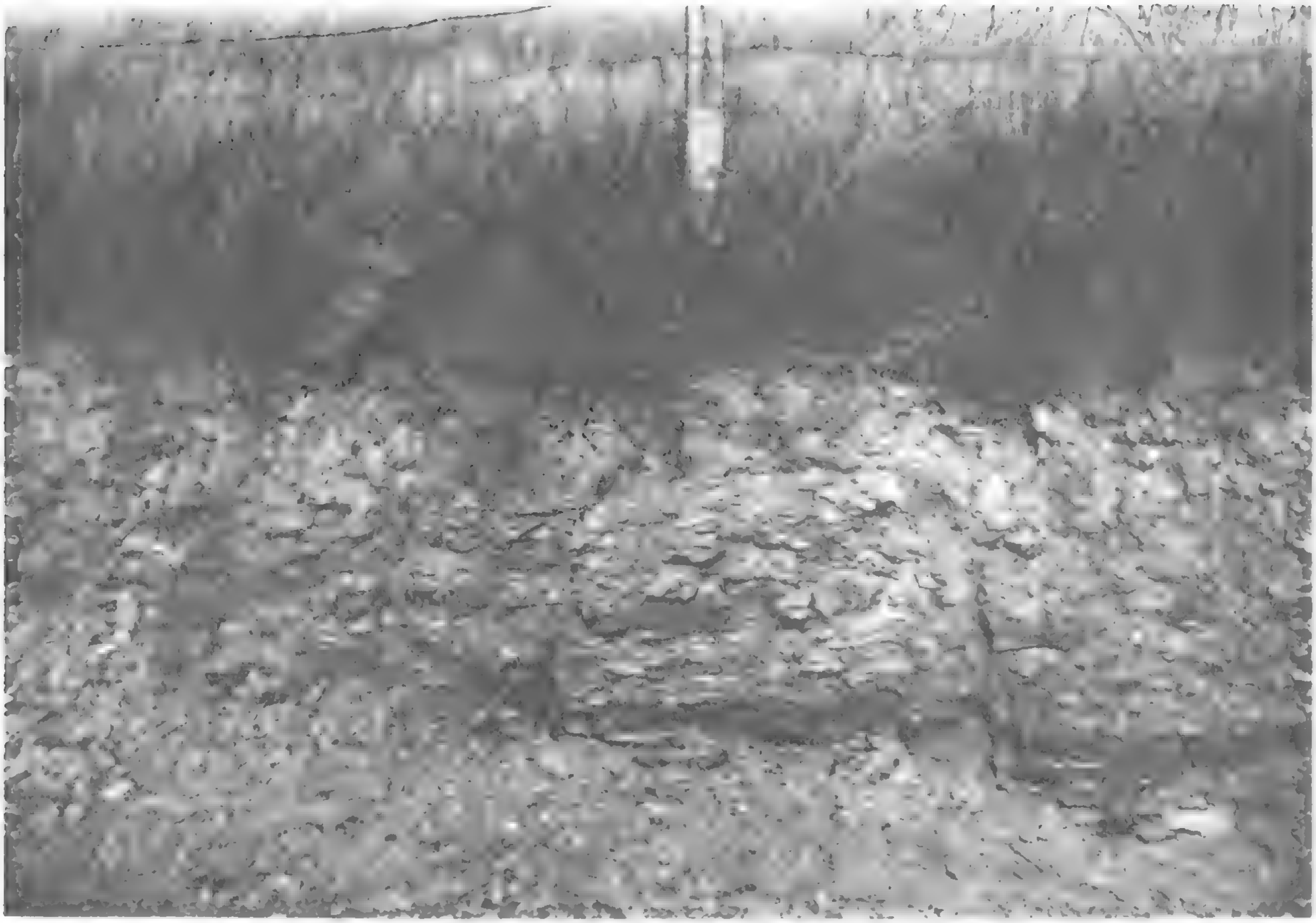

Figure 8.—**A profile of Kloten loam exposed in a road ditch in the western part of Walsh County.**

of 40 inches or more. Typically, the uppermost layer of this alluvial material is gray silty clay loam about 8 inches thick. The next layer, which is the surface layer of a buried soil, is very dark gray silty clay loam about 5 inches thick. Just beneath the buried horizon is a layer of gray, mottled silty clay loam about 9 inches thick. Underlying this layer is light-gray, mottled silty clay loam that extends to a depth of 60 inches or more.

Permeability is moderately slow, and the available water capacity is very high. A seasonal high water table rises to within 2 to 5 feet of the soil surface during wet periods.

Typical profile of a Lamoure silty clay loam in a cultivated field (550 feet east and 100 feet south of the northeast corner of NW¼, sec. 4, T. 155 N., R. 52 W.):

Ap—0 to 5 inches, dark-gray (5Y 4/1) silty clay loam, black (10YR 2/1) when moist; moderate, fine, granular structure; very hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous; contains a few snail shells; abrupt, smooth boundary.

A1—5 to 10 inches, dark-gray (5Y 4/1) silty clay loam, black (10YR 2/1) when moist; a few, fine, faint, brown mottles; moderate, medium and fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous; contains a few snail shells; clear, wavy boundary.

C1g—10 to 18 inches, gray (5Y 5/1) silty clay loam, very dark gray (5Y 3/1) when moist; common, fine, prominent, brown mottles; moderate, very fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; calcareous; abrupt boundary.

A1b—18 to 23 inches, very dark gray (N 3/0) silty clay loam, black (10YR 2/1) when moist; moderate, very fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous; abrupt boundary.

C2g—23 to 32 inches, gray (5Y 5/1) silty clay loam, very dark gray (5Y 3/1) when moist; common, fine, prominent, brown mottles and common, fine, faint, brown and gray mottles when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; calcareous.

C3g—32 to 45 inches, light-gray (5Y 7/2) silty clay loam, olive (5Y 5/3) when moist; common, fine, faint, brown mottles and common, fine, faint, gray mottles when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; calcareous; contains a few spots of black manganese oxide.

C4g—45 to 60 inches, light-gray (5Y 7/2) silty clay loam, olive (5Y 4/3) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; calcareous; contains a few spots of black manganese oxide.

Texture of the A horizon ranges from silt loam to silty clay loam or loam. Texture of the soil material below the A horizon ranges from silty clay loam or clay loam to silt loam or loam. Stratified sand and gravel underlie the finer textured material

below a depth of 40 inches in some places. These soils are calcareous throughout but they lack a strongly calcareous layer where lime has accumulated. Salinity throughout the profile ranges from none to moderate.

Lamoure soils, moderately saline (0 to 3 percent slopes) (Lo).—These soils are on bottom lands along streams and in intermittent drainageways. They are subject to flooding in spring and after intense rainstorms. In most places the floodwaters do not remain long, but water tends to pond in areas dissected by oxbows and by abandoned stream channels. These soils are moderately saline, contain white salt crystals throughout, and have a surface layer of silt loam in about 10 percent of the acreage.

Included with these soils in mapping were small areas of nonsaline Lamoure soils.

The chief limitations to use of these moderately saline Lamoure soils for crops are their poor natural drainage, moderate salinity, and moderate to high susceptibility to soil blowing if they are cultivated. Most of the acreage is in native grass. In cultivated areas all the crops are adversely affected by salts in the root zone. (Capability unit IIIws-4; windbreak site 9)

Lankin Series

The Lankin series consists of deep, somewhat poorly drained soils that have formed in lake sediment less than 36 inches thick and in clay loam glacial till. The native vegetation was tall prairie grasses.

In a typical profile, the surface layer is very dark gray loam about 7 inches thick. The subsoil is heavy loam, about 9 inches thick, that is dark gray in the upper part and is gray in the lower part. Just below the subsoil is a layer of mottled material, about 18 inches thick, where lime has accumulated. This layer has developed in the upper part of the glacial till, and it is clay loam in the upper part and is light-gray loam in the lower part. The next layer is light olive-gray, mottled clay loam glacial till that extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer and the subsoil, which formed in lacustrine sediment, and it is moderately slow in the glacial till substratum. The available water capacity is high. A seasonal high water table is within 2 to 5 feet of the soil surface during wet periods.

Typical profile of Lankin loam, level (985 feet east and 250 feet north of the southwest corner of sec. 8, T. 156 N., R. 54 W.):

Ap—0 to 7 inches, very dark gray (10YR 2/1) loam, black (10YR 2/1) when moist; cloddy; hard when dry, firm when moist, slightly sticky and plastic when wet; abrupt, smooth boundary.

B2—7 to 13 inches, dark-gray (10YR 4/1) heavy loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; clear, smooth boundary.

B3—13 to 16 inches, gray (10YR 5/1) heavy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure breaking to moderate, medium, angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; some mixing of soil material by earthworms; clear, smooth boundary.

IIC1ca—16 to 26 inches, white (10YR 8/1) clay loam, light yellowish brown (2.5Y 6/4) when moist; common, fine, faint, brown mottles; weak, medium, prismatic structure breaking to moderate, medium, angular blocky structure; slightly hard when dry, very friable when moist, sticky and plastic when wet; very strongly calcareous.

IIC2ca—26 to 34 inches, light-gray (5Y 7/2) loam, light yellowish brown (2.5Y 6/4) when moist; many, medium, distinct, light olive-brown mottles; weak, fine, subangular blocky and crumb structure; slightly hard when dry, very friable when moist, slightly sticky and plastic when wet; strongly calcareous.

IIC3—34 to 60 inches, light olive-gray (5Y 6/2) clay loam, olive brown (2.5Y 4/4) when moist; many, medium, prominent, olive-gray mottles and few, fine, distinct, strong-brown mottles; massive; hard when dry, very firm when moist, sticky and very plastic when wet; slightly calcareous.

The A horizon ranges from loam to silt loam or clay loam in texture and from 5 to 12 inches in thickness. The B horizon ranges from very dark gray to gray in color and from 6 to 18 inches in thickness. In places the B horizon is sandy loam or clay loam. Thickness of the layer of lacustrine sediment over glacial till ranges from 12 to 36 inches. In some areas the substratum contains layers of sandy loam that are believed to be the result of wave action when the waters of Lake Agassiz were at their highest level. In places enough glacial stones and boulders are scattered throughout the soil profile to interfere with fieldwork. These soils have a pebble line or a thin layer of gravelly material between the layer of lake sediment and the underlying glacial till in many places.

In contrast to the Gilby and Glyndon soils, the Lankin soils have a B horizon. Unlike the Gardena soils, they have a substratum of glacial till. The Lankin soils differ from the Svea soils by having A and B horizons formed in lake sediment rather than in glacial till.

Lankin loam, level (0 to 3 percent slopes) (LeA).—This soil occupies areas between sandy and gravelly beach ridges that extend in a north-south direction along the edge of the glacial lake basin. The areas are dotted with small depressions that are mainly 1 acre or less in size. Piles of stones that have been cleared from the surface of this soil are common. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were small areas of Lankin silt loam. Also included were small areas of Gilby loam, the major soil that is associated with Lankin loam. Generally, the Gilby and Lankin soils were separated in mapping, but in some places they are so intermingled that separation was not practical. For this reason, as much as 25 percent of some areas mapped as this soil is Gilby loam. Other inclusions consist of areas of Tonka silt loam in small depressions, and these areas make up about 5 percent of the acreage in this mapping unit.

Climate is the chief limitation to use of this Lankin soil for crops. In addition, this soil is slightly susceptible to soil blowing, and stones and boulders on the surface and ponded water in the depressions interfere with fieldwork in some areas. This soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county. (Capability unit IIc-6; windbreak site 1)

Lankin clay loam (0 to 3 percent slopes) (Lk).—This soil occupies areas between sandy and gravelly beach ridges that extend in a north-south direction along the edge of the glacial lake basin. The areas are dotted with many small depressions that are mainly less than 1 acre in size. Piles of stones that have been removed from the surface of this soil are common. The profile is similar to the one described as representative of the series, except that the surface layer and the subsoil are clay loam.

Included with this soil in mapping were areas of Antler clay loam and of Tonka silt loam and Gilby loam, wet, in the many small depressions. Together these included soils

make up from 15 to 25 percent of the acreage in this mapping unit.

Climate is the chief limitation to use of this Lankin soil for crops. In addition, this soil is slightly susceptible to soil blowing, and the stones and boulders on the surface and the ponded water in the depressions interfere with fieldwork in some areas. This soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county. (Capability unit IIc-6; windbreak site 1)

Lankin and Svea loams, nearly level (0 to 3 percent slopes) (LnA).—Soils of this mapping unit are on the lake plain and on glacial till plains along the western margin of the area that was formerly the basin of Lake Agassiz. About 50 percent of the mapping unit is Lankin loam, 40 percent is Svea loam, and the rest is Tonka, Parnell, and Cresbard soils. The Lankin soil is on the lake plain, and the Svea soil is on glacial till plains. The profiles of these soils are similar to the ones described as representative of their respective series, except that both the Lankin and Svea soils have a substratum that contains layers of sandy loam below a depth of 3½ feet. The layers of sandy loam range from 18 to 30 inches in thickness and are underlain by clay loam glacial till. Piles of stones that have been removed from the surface of these soils are common.

Climate is the chief limitation to use of these soils for crops. The soils are also slightly susceptible to soil blowing. In addition, the stones and boulders on the surface, and the ponded water in depressions, interfere with fieldwork in some areas. These soils are suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIc-6; windbreak site 1)

Lankin and Svea loams, gently sloping (3 to 5 percent slopes) (LnB).—Soils of this mapping unit are on the lake plain and on glacial till plains along the western margin of the area that was formerly the basin of Lake Agassiz. About 50 percent of the mapping unit is Lankin loam, gently sloping, and 40 percent is Svea loam, gently sloping. The rest consists of Svea loam, gently sloping, eroded, and of Svea loam, sloping, eroded.

The Lankin soil is on the side slopes of drainageways, and the Svea soil is on glacial till plains. Profiles of these soils are similar to the ones described as representative of their respective series, except that both the Lankin and Svea soils have a substratum that contains layers of sandy loam below a depth of 3½ feet. The layers of sandy loam range from 18 to 30 inches in thickness and are underlain by clay loam glacial till. Piles of stones that have been removed from the surface of these soils are common.

These soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Water erosion is the chief limitation to use of these soils for cultivated crops, but the soils are also slightly susceptible to soil blowing. (Capability unit IIe-6; windbreak site 1)

LaPrairie Series

The LaPrairie series consists of deep, moderately well drained soils that have formed in medium-textured and moderately fine textured alluvium. These soils are on flood plains and bottom lands along streams, on low levees or terraces, and on the side slopes of stream channels. The native vegetation was tall priarie grasses and deciduous trees and shrubs.

In a typical profile, the surface layer is dark-gray silt loam about 7 inches thick. The subsoil is about 27 inches thick and is dark grayish-brown silt loam in the upper part and is brown silty clay loam in the lower part. Beneath the subsoil is brown, stratified material that is silt loam in the upper part and is silty clay loam in the lower part. This stratified material extends to a depth of 60 inches or more.

Permeability is moderate in the layers of silt loam, and it is moderately slow in the layers of silty clay loam. The available water capacity is high or very high. Except when these soils are flooded, the water table is generally below a depth of 5 feet.

Typical profile of LaPrairie silt loam (180 feet east and 150 feet south of the east end of a highway bridge in the NW¼ of sec. 35, T. 158 N., R. 54 W.):

A1—0 to 7 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; moderate, medium, blocky structure breaking to moderate, very fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

B2—7 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, medium, prismatic structure breaking to moderate, medium and fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; gradual, smooth boundary.

B3—12 to 34 inches, brown (10YR 5/3) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; soft when dry, friable when moist, sticky and plastic when wet; very slightly calcareous, and contains a small amount of segregrated lime; gradual, smooth boundary.

C1—34 to 51 inches, brown (10YR 5/3) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, angular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; few nodules of segregated lime; slightly calcareous; gradual, smooth boundary.

C2—51 to 60 inches, brown (10YR 5/3) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; a few, fine, distinct, brownish mottles; moderate, fine, crumb structure; slightly hard when dry, friable when moist, sticky and plastic when wet; few roots; slightly calcareous and contains a few nodules of segregated lime.

The A horizon ranges from silt loam to silty clay loam in texture and from 7 to 16 inches in thickness. In some places the substratum contains alternating light-colored and very dark colored layers indicating that sometime in the past, material was deposited over a developed soil. The C horizons are generally calcareous, but these soils are noncalcareous throughout the profile in some places.

The LaPrairie soils have a thicker A horizon and have formed in older alluvium than the Fairdale soils, and unlike the Fairdale soils, they have a B horizon. They are better drained than the Rauville soils, and they have less clay throughout their profile than the Wahpeton soils.

LaPrairie silt loam (0 to 3 percent slopes) (Lp).—This soil is on flood plains, bottom lands, and low terraces along streams. It has formed in old alluvium that has a texture of silt loam in most places. The profile is the one described as representative of the series.

Included with this soil in mapping were small areas of LaPrairie silty clay loam and of Fairdale silt loam.

Climate is the chief limitation to use of this LaPrairie soil for crops, but this soil is also slightly susceptible to soil blowing. In addition, it is subject to flooding about 5

out of every 10 years, but it is suited to the commonly grown field crops, hay crops, and pasture plants. The floods are of short duration. Floodwaters drain off rapidly, and this soil can be cultivated soon after the floodwaters recede. (Capability unit IIc–6; windbreak site 1)

LaPrairie silty clay loam (0 to 3 percent slopes) (Lr).—This soil is mainly on flood plains, bottom lands, and low terraces adjacent to streams, but it is on side slopes along stream channels in a few places. The profile is similar to the one described as representative of the series, except that it is dominantly silty clay loam throughout.

Included with this soil in mapping were areas of sloping soils and of soils in stream channels that were too narrow to be mapped separately. Also included were small areas of Fairdale silty clay loam and of Fairdale silt loam that together make up less than 20 percent of the acreage in this mapping unit. Other inclusions consist of areas of LaPrairie-Fairdale soils, channeled, that are less than 160 feet wide.

In general, this LaPrairie soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Some areas have remained in native timber and in tall prairie grasses, however, and these areas are used for native pasture. Climate is the chief limitation to use of this soil for crops, but soil blowing is also a slight hazard. In addition, this soil is subject to flooding in spring. The floodwaters recede rapidly, and this soil is ready for cultivation reasonably early in spring. (Capability unit IIc–6; windbreak site 1)

Ludden Series

The Ludden series consists of deep, poorly drained soils that have formed in clayey alluvium on the flood plains of streams. These soils are in nearly level areas or in slight depressions. They are subject to long periods of flooding. The native vegetation was tall prairie grasses, wetland grasses, and salt-tolerant grasses.

In a typical profile, the surface layer is very dark gray, very slightly calcareous silty clay about 5 inches thick. Just beneath the surface layer is a layer of dark-gray silty clay alluvium about 9 inches thick. The next layer is the surface layer of a buried soil, and it consists of black silty clay, also about 7 inches thick. Beneath the buried horizon and extending to a depth of 60 inches or more is very dark gray silty clay.

Permeability is moderately slow, and the available water capacity is high. A high water table is within 0 to 5 feet of the surface during wet periods. It is nearest the surface when runoff occurs in spring. At that time, these soils are often flooded.

Typical profile of Ludden silty clay (200 feet north and 100 feet east of the southwest corner of sec. 12, T. 155 N., R. 52 W.):

A1—0 to 5 inches, very dark gray (10YR 3/1) silty clay, black (10YR 2/1) when moist; strong, very fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; very slightly calcareous; abrupt, smooth boundary.

C1g—5 to 14 inches, dark-gray (5Y 4/1) silty clay, very dark gray (5Y 3/1) when moist; moderate, medium, prismatic structure breaking to strong, very fine, angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; contains a trace of salts; slightly calcareous; clear boundary.

A1sab—14 to 21 inches, black (5Y 2/1) silty clay, black (5Y 2/1) when moist; strong, very fine, angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; from 2 to 4 percent of horizon is fine crystals of gypsum and salts; slightly calcareous; clear boundary.

C2gca—21 to 60 inches, very dark gray (5Y 3/1) silty clay, very dark gray (5Y 3/1) when moist; strong, very fine, angular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; strongly calcareous.

The A horizon is silty clay to clay in texture and is 5 to 10 inches thick. Reaction throughout the profile ranges from neutral to moderately alkaline. These soils are moderately saline below a depth of about 24 inches.

The Ludden soils have a more clayey profile than the Lamoure soils. They are more slowly permeable than the Rauville soils, and they lack the coarse sand and gravel in their substratum that are typical in the substratum of the Rauville soils.

Ludden silty clay (0 to 1 percent slopes) (Lu).—This soil is on flood plains, and it is subject to long periods of flooding. The profile is the one described as representative of the series.

Included with this soil in mapping were some areas of slightly saline and moderately saline soils. Also included were some soils that are very poorly drained.

Most areas of this Ludden soil have remained in native vegetation. A few areas are suited to the commonly grown field crops, hay crops, and pasture plants, and those areas are cultivated. In some places where outlets are available, drainage has been improved by constructing surface drains. (Capability unit IIw–4; windbreak site 10)

Ludden and Ryan soils (0 to 1 percent slopes) (Ly).—This mapping unit is dominantly Ludden and Ryan soils that are associated in such complex patterns that it was impractical to map them separately. About 20 percent of the mapping unit is Ludden silty clay, 35 percent is Ludden silty clay, strongly saline, and 45 percent is Ryan silty clay. These soils are on flood plains, and they are subject to flooding during wet periods. The floodwaters remain for long periods. The Ludden soils have a profile similar to the one described as representative of the Ludden series, except that a few to common white salt crystals are scattered throughout the profile in strongly saline areas. A typical profile for the Ryan soil is described under the Ryan series.

Most areas of these soils have remained in native vegetation. The main limitations to use of the soils for crops are their high content of salts and alkali, and their poor natural drainage. In pastured areas the stand of grass on the Ryan soil deteriorates under intensive grazing. Then, soil blowing removes the original surface layer, and shallow slickspots are formed. In some areas where outlets are available, drainage has been improved by constructing surface drains. (Capability unit VIs–SS; windbreak site 10)

Maddock Series

The Maddock series consists of deep, well-drained soils on former beaches and on interbeach plains. These soils have formed in sandy lacustrine deposits that in many areas have been reworked by wind. The native vegetation was mainly medium and tall prairie grasses.

In a typical profile, the surface layer is about 17 inches thick and consists of very dark gray light sandy loam in

the upper part and of dark grayish-brown loamy sand in the lower part. Just beneath the surface layer is stratified sand and fine sand. Sand that is brown in the upper part, light olive brown over grayish brown in the middle part, and light brownish gray in the lower part typically extends to a depth of about 58 inches. Below the sand and extending to a depth of 64 inches or more is light brownish-gray fine sand.

Maddock soils have moderately rapid permeability and low available water capacity. The water table is very deep.

Typical profile of a Maddock sandy loam (480 feet north and 150 feet west of the southeast corner of NE¼, sec. 29, T. 155 N., R. 55 W.):

A11—0 to 6 inches, very dark gray (10YR 3/1) light sandy loam, very dark brown (10YR 2/2) when moist; cloddy, breaking to weak, very fine, crumb structure; slightly hard when dry, friable when moist, slightly plastic when wet; abrupt, smooth boundary.

A12—6 to 17 inches, dark grayish-brown (10YR 4/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; weak, medium, prismatic structure breaking to weak, medium and coarse, subangular blocky structure; hard when dry, very friable when moist; clear, wavy boundary.

C1—17 to 25 inches, brown (10YR 5/3) sand, dark brown (10YR 4/3) when moist; weak, medium, subangular blocky structure; slightly hard when dry, very friable when moist; 10 percent of horizon is shale sand; abrupt boundary.

C2—25 to 38 inches, light olive-brown (2.5Y 5/4) sand, olive brown (2.5Y 4/4) when moist; weak, medium, subangular blocky structure; soft when dry, very friable when moist; 35 percent of horizon is shale sand.

C3—38 to 48 inches, grayish-brown (2.5Y 5/2) sand, dark yellowish brown (10YR 4/4) when moist; single grain; soft when dry, loose when moist; 10 percent of horizon is shale sand.

C4—48 to 58 inches, light brownish-gray (2.5Y 6/2) sand, olive brown (2.5Y 4/4) when moist; a few, faint, brown mottles; single grain; loose when dry or moist; slightly calcareous; 10 percent of horizon is shale sand.

C5—58 to 64 inches, light brownish-gray (2.5Y 6/2) fine sand, very dark grayish brown (2.5Y 3/2) when moist and a few, fine, distinct, brown mottles; many, medium, distinct, brown (7.5YR 4/4) and dark-gray (5Y 4/1) mottles when moist; single grain; soft when dry, loose when moist; slightly calcareous; 20 percent of horizon is shale sand.

Texture of the A horizon is loamy sand to sandy loam. Thickness of that horizon ranges from 6 inches in moderately eroded areas to 18 inches in noneroded areas. The C horizons are loamy sand, sand, fine sand, or coarse sand. The content of shale throughout the soil profile ranges from 10 percent to as much as 35 percent. In most places the soil profile is noncaclareous to a depth of 40 inches.

The Maddock soils have a thinner A horizon than the Hecla soils, and they lack the Cca horizon that is typical in the profile of the Ulen soils. The Maddock soils are better drained than the Hamar soils, and they lack the B horizon that is typical of the Embden soils.

Maddock-Hecla complex, severely eroded (0 to 9 percent slopes) (Mk3).—This mapping unit consists mainly of Maddock and Hecla loamy sands and sandy loams that occur in such complex patterns that it was not practical to map them separately. About 60 percent of the mapping unit is Maddock soils, 35 percent is Hecla soils, and 5 percent is other soils. The soils occupy small areas on the glacial lake plain and on interbeach plains.

Profiles of these soils are similar to the ones described as representative of their respective series, except that in many places the original surface layer has been lost through erosion. Some areas contain alternate shallow blowouts and low dunes. In the shallow blowouts, a thin surface layer remains. In places, where these soils are on low dunes, they contain a buried surface layer. In a few areas, the blowouts are less shallow and the sand dunes are higher. Most of the areas are now stabilized, but erosion is still active in a few areas.

The chief limitations to use of these soils for farming are their very high susceptibility to soil blowing and their droughtiness, caused by the low available water capacity. Most of the areas have remained in grass. (Capability unit VIe–Sa; the Maddock soil is in windbreak site 5, and the Hecla soil is in windbreak site 1)

Manfred Series

The Manfred series consists of deep, calcareous, very poorly drained soils that have formed in glacial till or in local alluvium and till. These soils are in closed depressions on the glacial till plain and on interbeach plains. The native vegetation was mainly wetland grasses.

In a typical profile, the surface layer is very dark gray silty clay loam about 10 inches thick. The subsoil is mottled, dark-gray silty clay about 3 inches thick. Just below the subsoil is a layer of mottled, light-gray, very strongly calcareous silty clay loam that is about 10 inches thick and contains a large amount of lime. The next layer is mottled, light olive-gray sandy clay loam alluvium about 7 inches thick. This is underlain by a layer of mottled, gray clay loam alluvium about 8 inches thick. Just beneath this layer and extending to a depth of 60 inches or more is mottled, light yellowish-brown clay loam alluvium.

In the surface layer and in the subsoil and the layer that contains a large amount of lime, permeability is moderate and the available water capacity is very high. Below these layers, permeability is slow and the available water capacity is high. The water table is at the surface or is within 5 feet of the surface during wet periods.

Typical profile of a Manfred silty clay loam (0.4 mile east and 50 feet north of the southwest corner of sec. 17, T. 156 N., R. 58 W.):

A1—0 to 10 inches, very dark gray (N 3/0) silty clay loam, black (5Y 2/1) when moist; moderate, medium and fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; calcareous; abrupt, irregular boundary; a layer of moss and organic mulch 1 inch thick covers the surface.

Btg—10 to 13 inches, dark-gray (5Y 4/1) silty clay, dark olive gray (5Y 3/2) when moist; a few, fine, distinct, olive-brown mottles; strong, fine, angular blocky structure; clay films are on ped surfaces; very hard when dry, firm when moist, very sticky and very plastic when wet; strongly calcareous; clear, wavy boundary.

C1gca—13 to 23 inches, light-gray (5Y 7/2) silty clay loam, olive gray (5Y 5/2) when moist; a few, fine, distinct, olive (5Y 4/4) mottles; moderate, very fine, subangular blocky structure; very hard when dry, firm when moist, sticky and very plastic when wet; very strongly calcareous; contains a few nodules of iron and manganese; clear boundary.

C2g—23 to 30 inches, light olive-gray (5Y 6/2) sandy clay loam, olive gray (5Y 5/2) when moist; many, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, medium, angular blocky structure breaking to moderate, fine, granular structure; very hard when dry, friable when moist, sticky and plastic when wet; calcareous; contains a few nodules of iron and manganese; about 5 percent of horizon is fine gravel; clear, wavy boundary.

C3g—30 to 48 inches, gray (5Y 6/1) clay loam, olive gray (5Y 5/2) when moist; many, fine, prominent, yellowish-brown (10YR 5/6) mottles; massive; very hard when dry, firm when moist, sticky and plastic when wet; calcareous; glacial till of which about 5 percent is granitic and shale pebbles.

C4—48 to 60 inches, light yellowish-brown (2.5Y 6/4) clay loam, olive brown (2.5Y 4/4) when moist; common, fine, prominent, gray (N 5/0) mottles; massive; very hard when dry, firm when moist, sticky and plastic when wet; calcareous glacial till.

The A horizon is black or very dark gray, and it ranges from clay loam or silty clay loam to loam in texture. Depth to the Cca horizon ranges from 6 to 18 inches. Nests of gypsum crystals and nodules of iron and manganese are common in the B and C horizons.

Unlike the Parnell and Tonka soils, the Manfred soils have a Cca horizon close to the surface. They are more poorly drained than the Vallers soils, and they lack the sandy and gravelly C horizon that is typical of the Arveson and Benoit soils.

Manfred soils (0 to 1 percent slopes) (Mn).—These soils are in closed depressions on the glacial till plains and on interbeach plains. They receive runoff from adjacent areas, and water sometimes ponds on their surface. At other times, the water table is only a few inches below the surface for long periods. The surface layer is clay loam, silty clay loam, or loam.

Included with these soils in mapping were small areas of Parnell soils in slightly lower depressions than those occupied by the Manfred soils.

The chief limitation to use of these Manfred soils for crops is their very poor natural drainage. Artificial drainage is generally impractical. Where drained, these soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county, but most of the acreage is in native vegetation. (Capability unit Vw–WL; in windbreak site 2 if drained, but in windbreak site 10 if undrained)

Ojata Series

The Ojata series consists of deep, poorly drained, strongly saline soils that have formed in medium-textured and moderately fine textured lacustrine sediment and alluvium. These soils are on glacial lake plains and on bottom lands along streams. The native vegetation was tall prairie grasses, wetland grasses, and salt-tolerant grasses.

In a typical profile, the surface layer is very dark gray, slightly calcareous silty clay loam about 5 inches thick. The surface is bare, and a thin accumulation of white salt covers the surface in many places. Just beneath the surface layer is a layer of dark-gray, mottled, strongly calcareous silty clay loam that is about 7 inches thick and contains a large amount of lime. Underlying this layer is a layer of dark grayish-brown, mottled, calcareous silty clay loam sediment that extends to a depth of 60 inches or more.

The Ojata soils are slowly permeable and have moderate available water capacity. A seasonal high water table rises to within 2 to 4 feet of the soil surface during wet periods.

Typical profile of an Ojata silty clay loam (800 feet south and 50 feet east of the northwest corner of the SW¼ of sec. 4, T. 155 N., R. 52 W.):

A1—0 to 5 inches, very dark gray (5Y 3/1) silty clay loam, black (5Y 2/1) when moist; moderate, fine, granular structure; plastic and sticky when wet; common, fine, salt nests; slightly calcareous; abrupt boundary.

C1gca—5 to 12 inches, dark-gray (5Y 4/1) silty clay loam, very dark gray (5Y 3/1) when moist; common, fine, distinct, brown mottles; weak, very coarse, angular blocky structure; sticky and plastic when wet; common, fine, salt nests; strongly calcareous; abrupt boundary.

C2g—12 to 60 inches, dark grayish-brown (2.5Y 4/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; many, medium, distinct, brown and gray mottles; moderate, fine, angular blocky structure; sticky and plastic when wet; calcareous.

Texture of the A horizon ranges from loam to silty clay loam, and color of that horizon ranges from very dark gray to very dark brown or black. Texture of the C horizons ranges from very fine sandy loam to clay. Grade of structure in the C horizons ranges from weak to strong, and size of the peds ranges from very fine to very coarse. These soils are strongly or very strongly saline and are moderately to strongly alkaline throughout.

Ojata soils (0 to 1 percent slopes) (Oa).—These soils occupy small areas on the lake plain, on bottom lands along streams, and in the basin of Lake Ardoch. They have a surface layer of silty clay loam or silt loam and are strongly or very strongly saline.

Nearly all of the acreage is in native vegetation and is used for hay or pasture. The chief limitation to use of these soils for crops is their high content of salts and alkali, but poor drainage is also a major limitation. (Capability unit VIs–SS; windbreak site 10)

Overly Series

The Overly series consists of deep, moderately well drained soils that have formed in moderately fine textured and fine textured lacustrine deposits on the glacial lake plain. The areas are marked by only a few depressions. The native vegetation was tall prairie grasses.

In a typical profile, the surface layer is very dark gray silty clay loam about 10 inches thick. The subsoil is silty clay loam that is about 10 inches thick and is dark gray in the upper part and is grayish brown and strongly calcareous in the lower part. Just below the subsoil is a layer of silty clay loam that is about 18 inches thick and contains a large amount of lime. This layer is light brownish gray and very strongly calcareous in the upper part and is light yellowish brown and strongly calcareous in the lower part. It is underlain by stratified lacustrine sediment that is light olive-brown, mottled silty clay in the upper part and is pale-olive, mottled, stratified silty clay loam and silty clay in the lower part. The lacustrine sediment extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer of most of these soils, but it is moderately slow where the surface layer is silty clay. Below the surface layer, permeability is slow in the finer textured layers. It is moderately slow in the other layers. These soils have high or very high available water capacity. The water table is very deep.

Typical profile of Overly silty clay loam, level, in a cultivated field (300 feet east and 150 feet south of the northwest corner of sec. 18, T. 155 N., R. 53 W.):

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; moderate, fine, granular structure; firm when moist, sticky and plastic when wet; abrupt, smooth boundary.

A1—5 to 10 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; moderate, coarse and medium, angular blocky structure breaking to moderate, fine, subangular blocky structure;

firm when moist, sticky and plastic when wet; clear boundary.

B2—10 to 17 inches, dark-gray (10YR 4/1) silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, prismatic structure breaking to moderate, fine, angular blocky structure; continuous, distinct clay films on the vertical surfaces of the fine blocks, and patchy clay films on the horizontal surfaces; firm when moist, sticky and plastic when wet; clear, wavy boundary.

B3ca—17 to 20 inches, grayish-brown (2.5Y 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; few, fine, faint, brown mottles; moderate, fine, subangular blocky structure; firm when moist, sticky and very plastic when wet; strongly calcareous.

C1ca—20 to 28 inches, light brownish-gray (2.5Y 6/2) silty clay loam, light olive brown (2.5Y 5/4) when moist; moderate, medium, angular blocky structure breaking to moderate, fine, crumb structure; friable when moist, sticky and plastic when wet; very strongly calcareous; few crystals of gypsum.

C2ca—28 to 38 inches, light yellowish-brown (2.5Y 6/4) silty clay loam, olive brown (2.5Y 4/4) when moist; moderate, very fine, subangular blocky structure; firm when moist, sticky and plastic when wet; strongly calcareous.

C3—38 to 48 inches, light olive-brown (2.5Y 5/4) silty clay, olive brown (2.5Y 4/4) when moist; common, medium, distinct, yellowish-brown and light-gray mottles when dry; massive; very firm when moist, very sticky and very plastic when wet; slightly calcareous; contains a few crystals of gypsum and nodules of lime.

C4—48 to 60 inches, pale-olive (5Y 6/3), stratified silty clay loam and silty clay; olive (5Y 5/3) when moist; many, coarse, prominent, gray mottles; massive; firm when moist, sticky and plastic when wet; slightly calcareous; contains a few crystals of gypsum.

The A horizon ranges from silt loam to silty clay loam or silty clay in texture and from 7 to 16 inches in thickness. Depth to the Cca horizon ranges from 17 to 29 inches. In some areas where floodwaters have deposited sediment over the lake plain, the profile contains the very dark colored surface layer of a buried soil.

The Overly soils have less lime in the upper part of their profile than the Bearden soils, and unlike the Bearden soils, they have a B horizon. They have more clay throughout their profile than the Gardena soils, and they are better drained than the Colvin and Perella soils. The Overly soils are better drained and are deeper over glacial till than the Lankin soils, and they are better drained and have less clay throughout their profile than the Fargo soils.

Overly silt loam, level (0 to 3 percent slopes) (OeA).—This soil is on the part of the lake plain, where there are only a few depressions in which water ponds during wet periods. The profile is similar to the one described as representative of the series, except that the surface layer is silt loam and the subsoil is dark grayish brown.

Included with this soil in mapping were small areas of Glyndon silt loam and some sloping areas along shallow drainageways.

Climate is the chief limitation to use of this Overly soil for crops, but this soil is also slightly susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and nearly all of the acreage is cultivated. (Capability unit IIc–6; windbreak site 1)

Overly silty clay loam, level (0 to 3 percent slopes) (OlA).—This soil occurs where the lake plain is marked by only a few depressions in which water ponds during wet periods. The profile is the one described as representative of the series.

Included with this soil in mapping were small areas of Bearden silty clay loam.

Climate is the chief limitation to use of this Overly soil for crops, but this soil is also slightly susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, most of the acreage is cultivated. (Capability unit IIc–6; windbreak site 1)

Overly silty clay loam, gently sloping (3 to 6 percent slopes) (OlB).—This soil occupies areas along drainageways that dissect the lake plain. The profile is similar to the one described as representative of the series, except that the surface layer is thinner and is lighter colored as the result of water erosion.

Included with this soil in mapping were small areas of gently sloping Overly soils that have a silt loam surface layer and are moderately eroded. Also included were some areas of Overly silty clay loam, fans, that have received fresh sediment deposited by floodwaters during periods of high water.

This Overly soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. Where this soil is fallowed or is used for row crops, water erosion is the chief hazard, but this soil is also slightly susceptible to soil blowing. (Capability unit IIe–6; windbreak site 1)

Overly silty clay loam, sloping (6 to 9 percent slopes) (OlC).—This soil is on the side slopes of large drainageways. It has a profile similar to the one described as representative of the series. The surface layer is much thinner, however, and in places it contains some material from the subsoil that has been mixed with the surface layer during tillage. In some areas where this soil is on the crests of slopes, all of the original surface layer and subsoil have been lost through erosion, and the remaining soil material is strongly calcareous and is light colored.

Included with this soil in mapping were areas of Overly soils that have a surface layer of silt loam. These included soils make up as much as 50 percent of some areas of this mapping unit.

This Overly soil is suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. Water erosion is the chief hazard where this soil is cultivated, but this soil is also slightly susceptible to soil blowing. (Capability unit IIIe–6; windbreak site 1)

Overly silty clay loam, fans (0 to 3 percent slopes) (Om).—This soil is in areas where floodwaters have deposited recent material over the lacustrine sediment. The areas are slightly above the general level of the lake plain. Therefore, surface drainage is slightly better than in lower areas. Little runoff accumulates in the shallow depressions. The profile of this soil is similar to the one described as representative of the series, except that it contains one or more very dark colored surface layers of buried soils.

Climate is the chief limitation to use of this soil for crops, but soil blowing is also a slight hazard. This soil is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIc–6; windbreak site 1)

Overly silty clay, level (0 to 3 percent slopes) (OvA).—This soil is on a part of the lake plain where there are only a few depressions in which water ponds during wet periods. The profile is similar to the one described as representative of the series, except that the surface layer and the

upper part of the subsoil contain more clay, and permeability to water and air is slower.

This soil is moderately to highly susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIe-4; windbreak site 1)

Overly silty clay, fans (0 to 3 percent slopes) (Ow).—This soil is on a part of the lake plain where floodwaters have deposited a thick layer of alluvium over the lake sediment. The plain is marked by only a few depressions in which water ponds during wet periods. The profile is similar to the one described as representative of the series, except that it has more clay in the surface layer and the upper part of the subsoil. In addition, the profile contains the surface layer of a buried soil, and internal drainage is somewhat slower.

This soil is moderately to highly susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIe-4; windbreak site 1)

Parnell Series

The Parnell series consists of deep, very poorly drained soils that have formed in moderately fine textured local alluvium over glacial till. These soils are in shallow to deep, closed depressions on the glacial till plain. They are ponded during wet periods, and those in the deeper depressions are sometimes ponded all year when precipitation is above normal. The depressions range from less than 2 acres to more than 40 acres in size, but most of them occupy less than 10 acres. The native vegetation was wetland grasses, reeds, rushes, and sedges.

In a typical profile, the surface layer is about 19 inches thick and consists of silty clay loam that is very dark gray in the upper part and is dark gray in the lower part. The subsoil is dark-gray silty clay about 18 inches thick. A substratum of mottled, gray clay alluvium underlies the subsoil and extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer, moderately slow in the subsoil, and slow in the substratum. The available water capacity is very high. A seasonal high water table is at the surface or is within 5 feet of the surface during wet periods.

Typical profile of Parnell silty clay loam (0.1 mile east and 400 feet south of the northwest corner of the NE¼ of sec. 21, T. 157 N., R. 58 W.):

A11—0 to 5 inches, very dark gray (10YR 3/1) silty clay loam, black (N 2/0) when moist; weak, fine, crumb structure; soft when dry, loose when moist, sticky and plastic when wet; clear boundary.

A12—5 to 11 inches, very dark gray (10YR 3/1) light silty clay loam, black (N 2/0) when moist; weak, fine, crumb structure; slightly hard when dry, loose when moist, sticky and plastic when wet; clear boundary.

A13—11 to 19 inches, dark-gray (10YR 3.5/1) silty clay loam, black (N 2/0) when moist; moderate, thin, platy structure breaking to very fine crumb structure; hard when dry, friable when moist, sticky and plastic when wet; abrupt, wavy boundary.

B2tg—19 to 27 inches, dark-gray (5Y 4/1) silty clay, black (N 2/0) when moist; moderate, medium, prismatic structure breaking to strong, fine, subangular blocky structure; continuous, distinct clay films on all ped surfaces; few nodules of manganese.

B3g—27 to 37 inches, dark-gray (5Y 4/1) silty clay, very dark gray (5Y 2.5/1) when moist; strong, fine, granular structure; very hard when dry, firm when moist, very sticky and very plastic when wet; clear boundary.

Cg—37 to 60 inches, gray (5Y 6/1) clay, olive gray (5Y 4/2) when moist; common, fine, distinct mottles that increase in number with increasing depth; massive; very hard when dry, very firm when moist, very sticky and very plastic when wet.

The A horizon ranges from silty clay loam to silt loam in texture. The B horizon ranges from silty clay or clay to clay loam in texture, and it is very dark gray in places. Depth to the C horizon ranges from 20 to 40 inches. Thickness of the C horizon ranges from only a few inches to several feet. Glacial till is at some depth between 2 and 5 feet in most places, but it is at a greater depth in some areas. In some places the C horizon has an olive color. The number of mottles in the C horizon increases with increasing depth. These soils are noncalcareous to a depth of 5 feet in most places, but in some places a layer of lime accumulation is below a depth of 24 inches. Snail shells and nodules of manganese and segregated lime are common throughout the soil profile.

The Parnell soils lack the leached A2 horizon that is typical of the Tonka soils. They lack the prominent Cca horizon that is typical of the Manfred and Vallers soils.

Parnell silty clay loam (0 to 1 percent slopes) (Pa).—This soil is on the glacial till plain in some of the deeper depressions. Because runoff from snowmelt and from rains of high intensity collects in the depressions, water is ponded on the surface from early in spring to midsummer. When the amount of precipitation is above normal, water is sometimes ponded on the surface throughout the entire year. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping were small areas of a Vallers soil along the rims of the depressions.

The chief limitation to use of this Parnell soil for crops is its very poor drainage. Most of the acreage is in native vegetation and is used for growing hay and for wildlife habitat. A few areas have been drained. In those places this soil is well suited to the commonly grown field crops, hay crops, and pasture plants. (Capability unit Vw-WL; in windbreak site 2 if drained, but in windbreak site 10 if undrained)

Parnell and Tonka soils (0 to 1 percent slopes) (Pt).—About 55 percent of this mapping unit is Parnell silty clay loam, 40 percent is Tonka silt loam, and the rest is associated soils. These soils occur in closed depressions of the glacial till plain and in interbeach areas. The Parnell soil is in the deeper, wetter parts of the depressions, and the Tonka soil is in the parts that are slightly less wet. In some places these soils are in separate depressions that are so close together the soils are mapped as one unit. The Parnell soil has a profile similar to the one described as representative of the Parnell series, except that the surface layer and the subsoil are thinner and the surface layer contains less organic matter. A typical profile for the Tonka soil is described under the Tonka series.

Included with these soils in mapping were small areas of Vallers soils along the edges of the depressions.

The chief limitation to use of the soils of this mapping unit for crops is their poor or very poor drainage. Areas that are drained are well suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Those that are not drained are suited to late-seeded crops in most years when precipitation is normal. Where outlets are available, drainage can be improved by constructing surface drains. (Capability unit IIw-6; windbreak site 2)

Perella Series

The Perella series consists of deep, poorly drained soils in small, shallow depressions on the glacial lake plain. These soils have formed in medium-textured and moderately fine textured glacial lake sediment. They are ponded during wet periods. The native vegetation was tall prairie grasses and wetland grasses.

In a typical profile, the surface layer is black silty clay loam about 13 inches thick. The subsoil is very dark gray silty clay loam about 10 inches thick. Just below the subsoil is a layer that is about 17 inches thick and that contains a large amount of lime. This layer is strongly calcareous silt loam that is dark gray in the uppermost 4 inches and is olive in the lower 13 inches. Light yellowish-brown, stratified clay lacustrine sediment underlies the layer that contains a large amount of lime, and it extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer and the subsoil. It is moderately slow in the layer that contains a large amount of lime, and it is moderately slow or slow below the limy material. The available water capacity is high. A seasonal high water table is at the surface or is within 5 feet of the surface during wet periods.

Typical profile of Perella silty clay loam in a cultivated field (0.15 mile north and 160 feet west of the southeast corner of the NE¼ of sec. 10, T. 156 N., R. 52 W.):

A1—0 to 13 inches, black (10YR 2/1) silty clay loam, black (10YR 2/1) when moist; cloddy, breaking to moderate, medium, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous; clear, wavy boundary.

B2—13 to 23 inches, very dary gray (10YR 3/1) silty clay loam, very dark brown (10YR 2/2) when moist; weak, very fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous; clear, wavy boundary.

C1ca—23 to 27 inches, dark-gray (10YR 4/1) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; common, fine, distinct, white segregations of lime; weak, very fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; clear boundary.

C2ca—27 to 40 inches, olive (5Y 5/3) silt loam, dark grayish brown (2.5Y 4/2) when moist; a few, fine, faint, yellow (2.5Y 7/6) mottles and a few, fine, faint, brownish-yellow (10YR 6/8) mottles when moist; weak, very fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous.

IIC3—40 to 60 inches, light yellowish-brown (2.5Y 6/4) clay, olive brown (2.5Y 4/4) when moist; many, fine, faint, brownish-yellow (10YR 6/8) mottles; massive; very hard when dry, firm when moist, sticky and plastic when wet; calcareous.

The A and B horizons range from silt loam to silty clay loam in texture and from 18 to 25 inches in total thickness. In places these horizons are noncalcareous.

The Perella soils are more poorly drained than the Overly soils. They are more poorly drained and are deeper over the Cca horizon than the Colvin, Glyndon, and Bearden soils, and unlike those soils, they have a B horizon.

Perella silty clay loam (0 to 1 percent slopes) (Pu).—This is the only soil of the Perella series mapped in Walsh County. It is in shallow depressions on the glacial lake plain, where water ponds on its surface during wet periods.

Included with this soil in mapping were small areas of Perella silt loam and of Colvin silty clay loam.

Poor drainage is the chief limitation to use of this Perella soil for crops. Much of the acreage has been drained, however, and is suited to the commonly grown field crops, hay crops, and pasture plants. Where outlets are available, drainage can be improved in some areas by constructing field drains. (Capability unit IIw-6; windbreak site 2)

Rauville Series

The Rauville series consists of deep, very poorly drained soils that have formed in alluvium. These soils are on bottom lands of intermittent streams, and they also occupy alluvial fans on interbeach plains. The native vegetation was wetland grasses, sedges, and rushes.

In a typical profile, the surface layer is about 20 inches thick, and it is dark gray and slightly calcareous. The uppermost 9 inches of the surface layer is silt loam, the next 6 inches is loam, and the lower 5 inches is sandy loam. The surface layer is underlain by layers of gray, slightly calcareous alluvium. Typically, the layer just beneath the surface layer is gravelly sand about 22 inches thick. The next layer is silty clay that extends to a depth of 60 inches or more.

These soils have moderate permeability and high available water capacity in the surface layer. They have slow to rapid permeability and low to high available water capacity below the surface layer, depending on the texture of the various layers. The average available water capacity is moderate. A seasonal high water table is at the surface or is within 3 feet of the surface during wet periods.

Typical profile of a Rauville silt loam (750 feet south and 120 feet east of the northeast corner of the SE¼ of sec. 6, T. 155 N., R. 55 W.):

A11—0 to 9 inches, dark-gray (N 4/0) silt loam, black (10YR 2/1) when moist; weak, medium and fine, subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous; abrupt boundary.

A12—9 to 15 inches, dark-gray (5Y 4/1) loam, black (5Y 2/1) when moist; massive; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous; abrupt boundary.

A13—15 to 20 inches, dark-gray (5Y 4/1) sandy loam, black (5Y 2/1) when moist; massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous; abrupt boundary.

IIC1g—20 to 42 inches, gray (5Y 5/1) gravelly sand, dark greenish gray (5GY 4/1) when moist; single grain; loose when dry or moist; slightly calcareous; contains a few stones 4 to 6 inches in diameter.

IIIC2g—42 to 60 inches, gray (5Y 6/1) silty clay, dark greenish gray (5GY 4/1) when moist; massive; very hard when dry, sticky and plastic when wet; slightly calcareous.

Texture of the A horizon ranges from sandy loam to silty clay loam. The C horizons vary widely in texture and thickness. Depth to gravelly material ranges from 20 to 60 inches. Gravelly sand is at a shallower depth in these soils then in the defined range for the series, but this does not alter the usefulness and behavior of the soils.

The Rauville soils are more poorly drained than the Lamoure and Ludden soils. They have more sand and gravel in the uppermost 40 inches than the Lamoure soils, and they contain less clay than the Ludden soils.

Rauville soils (0 to 1 percent slopes) (Ra).—These soils are on bottom lands along intermittent streams. They also occupy alluvial fans on interbeach plains.

Included with these soils in mapping were soils in abandoned stream channels and oxbows, and small areas of Lamoure silty clay loam.

The chief limitation to use of these soils for crops is their very poor natural drainage. Nearly all of the acreage remains in native vegetation that is used for grazing late in summer and in fall and as wildlife habitat. (Capability unit Vw–WL; windbreak site 10)

Renshaw Series

The Renshaw series consists of excessively drained soils that have formed in loamy material over loose sand and gravel. These soils are on glacial outwash plains. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is very dark brown loam about 6 inches thick. The subsoil is very dark grayish brown and is about 12 inches thick. It is sandy clay loam in the upper part and is gravelly loam in the lower part. The layer just beneath the subsoil is very pale brown, pale brown, and brown, calcareous gravel. The next layer is pale-brown coarse sand that contains some gravel and extends to a depth of 60 inches or more.

These soils have moderate permeability and high available water capacity in the surface layer and the subsoil and rapid permeability and very low available water capacity in the substratum. The average available water capacity is low, and the water table is very deep.

Typical profile of Renshaw loam, nearly level (1,200 feet east and 200 feet north of the southwest corner of sec. 23, T. 156 N., R. 56 W.):

A1—0 to 6 inches, very dark brown (10YR 2/2) loam, black (10YR 2/1) when moist; moderate, fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, smooth boundary.

B2—6 to 15 inches, very dark grayish-brown (10YR 3/2) sandy clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, prismatic structure breaking to strong, medium, angular blocky structure; patches of clay films on the vertical surfaces of peds; hard when dry, firm when moist, sticky and plastic when wet; clear, smooth boundary.

B3—15 to 18 inches, very dark grayish-brown (10YR 3/2) gravelly loam, very dark brown (10YR 2/2) when moist; weak, medium, prismatic structure breaking to weak, fine, angular blocky structure; patches of clay films on the vertical surfaces of peds; hard when dry, firm when moist, sticky and plastic when wet; abrupt boundary.

IIC1ca—18 to 24 inches, very pale brown (10YR 8/3), pale brown (10YR 6/3), and brown (10YR 5/3) gravel, dark brown (10YR 4/3) when moist; about 10 percent of horizon is shale; single grain; calcareous.

IIIC2—24 to 60 inches, pale-brown (10YR 6/3) coarse sand; about 10 percent of horizon is shale gravel and other gravel.

Texture of the A horizon is sandy loam in some places, and that of the B2 horizon is sandy clay loam, sandy loam, or gravelly loam. Depth to stratified coarse sand and gravel ranges from 15 to 20 inches.

The Renshaw soils are deeper over sand and gravel than the Sioux soils. Unlike the Brantford soils, they are underlain by crystalline gravel and sand that contain little shale.

Renshaw loam, nearly level (0 to 3 percent slopes) (ReA).—This soil is on glacial outwash plains and on low glacial beach lines. It has the profile described as representative of the series.

Included with this soil in mapping were areas of soils that are in a few shallow depressions and that are often wet because water from snowmelt or rainfall has ponded on their surface. Also included were areas of soils that have lost part of their original surface layer as a result of soil blowing. These eroded soils have a thinner, lighter colored, and slightly coarser textured surface layer than typical for Renshaw soils.

The chief limitations to use of this Renshaw soil for crops are droughtiness, caused by the shallow root zone and the low available water capacity of the substratum, and moderate susceptibility to soil blowing. This soil is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIIs–5; windbreak site 6)

Renshaw loam, gently sloping (3 to 9 percent slopes) (ReB).—This soil is on sandy and gravelly glacial terraces and beaches. It has a profile similar to the one described as representative of the series, except that the surface layer and the subsoil are thinner.

Included with this soil in mapping were small areas of Sioux soils and small areas of a soil that has a gravelly surface layer. Also included were areas of Renshaw sandy loam and of Arvilla loam that make up a small part of some areas of this mapping unit.

The chief limitations to use of this Renshaw soil for crops are the moderate susceptibility to soil blowing, and droughtiness caused by the shallow root zone and the low available water capacity of the substratum. This soil is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIIes–5; windbreak site 6)

Rockwell Series

The Rockwell series consists of deep, poorly drained soils in interbeach areas. These soils have formed in coarse textured and moderately coarse textured sediment that is less than 40 inches thick over loamy glacial till or lacustrine sediment. The native vegetation was mainly medium and tall prairie grasses, but it included some wetland grasses, rushes, and sedges in wet areas.

In a typical profile, the surface layer is black fine sandy loam about 8 inches thick. Just beneath the surface layer is a layer that is about 11 inches thick and that contains a large amount of lime. This layer is light-gray, faintly mottled fine sandy loam in the upper part and is light-gray, faintly mottled loamy fine sand in the lower part. The next layer is about 7 inches thick and consists of light-gray fine sandy loam in the upper part and of pale-yellow fine sandy loam in the lower part. It is underlain by pale-yellow, mottled clay loam glacial till or lacustrine sediment that extends to a depth of 60 inches or more.

Permeability is moderately rapid in the upper part of the profile, where the soil material is coarse textured or moderately coarse textured, and it is moderately slow in the loamy lower layers. The available water capacity is high. A seasonal high water table is within 1 to 2 feet of the soil surface.

Typical profile of Rockwell fine sandy loam in a cultivated field (0.1 mile north and 200 feet west of the southeast corner of the NE¼ of sec. 24, T. 156 N., R. 55 W.):

Ap—0 to 8 inches, black (10YR 2/1) fine sandy loam, black (10YR 2/1) when moist; cloddy, breaking to weak,

fine, crumb structure; slightly hard when dry, friable when moist, slightly plastic when wet; slightly calcareous; abrupt boundary.

C1ca—8 to 11 inches, light-gray (5Y 7/1) fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; a few, fine, faint, brown mottles; single grain; slightly hard when dry, friable when moist, slightly plastic when wet; very strongly calcareous; contains a few nodules of manganese; abrupt, wavy boundary.

C2ca—11 to 19 inches, light-gray (2.5Y 7/2) loamy fine sand, light olive brown (2.5Y 5/4) when moist; a few, fine, faint, brown mottles; single grain; soft when dry, very friable when moist; very strongly calcareous; contains a few nodules of manganese; clear boundary.

C3—19 to 22 inches, light-gray (5Y 7/2) fine sandy loam, pale olive (5Y 6/3) when moist; single grain; slightly hard when dry, very friable when moist; strongly calcareous; contains a few nodules of manganese and a few pebbles; clear boundary.

C4—22 to 26 inches, pale-yellow (2.5Y 8/4) fine sandy loam, olive (5Y 5/4) when moist; single grain; slightly hard when dry, very friable when moist; strongly calcareous; contains a few nodules of manganese and a few pebbles; abrupt, wavy boundary.

IIC5—26 to 32 inches, pale-yellow (5Y 8/3) clay loam, olive (5Y 5/3) when moist; common, fine, faint mottles; moderate, fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; strongly calcareous.

IIC6—32 to 52 inches, pale-yellow (5Y 7/3) clay loam, olive (5Y 4/3) when moist; many, fine, distinct, brown and gray mottles; massive; very hard when dry, firm when moist, sticky and plastic when wet; strongly calcareous; contains a few crystals of gypsum.

IIC7—52 to 60 inches, pale-yellow (2.5Y 7/4) clay loam glacial till, olive brown (2.5Y 4/4) when moist; common, medium, prominent, gray (5Y 5/1) and yellowish-brown (10YR 5/8) mottles; massive; very hard when dry, very firm when moist, sticky and plastic when wet; calcareous.

Texture of the C horizons above the IIC5 horizon ranges from fine sandy loam to loamy fine sand. That of the IIC horizons ranges from silt or silt loam to silty clay loam or clay loam. Pebbles and stones are common in the IIC horizons. In some places a pebble or stone line separate the C4 horizon and the IIC5 horizon. Depth to the IIC5 horizon ranges from 20 to 40 inches.

The Rockwell soils are coarser textured than the Gilby soils, and they are more poorly drained than the Towner soils. The Rockwell soils lack the B horizon that is typical in the Lankin profile, and they are coarser textured than the Lankin soils.

Rockwell fine sandy loam (0 to 3 percent slopes) (Ro).—This is the only soil of the Rockwell series mapped in Walsh County. It is in interbeach areas that are dotted by a few shallow depressions in which runoff ponds during wet periods. This soil contains some stones, and a few stone piles are a part of the landscape.

Included with this soil in mapping were a few areas in which soil blowing has been active, and the surface layer in these areas is thinner, slightly coarser textured, and more limy than normal for Rockwell soils. Also included were areas of soils in which glacial till is below a depth of 60 inches. Other inclusions consist of areas of Tonka and Parnell soils in shallow depressions.

The high susceptibility to soil blowing in cultivated areas and the poor natural drainage are the chief limitations to use of this Rockwell soil for crops. This soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. (Capability unit IIIe-3M; windbreak site 2)

Ryan Series

The Ryan series consists of deep, poorly drained soils in depressions on the glacial lake plain and on bottom lands along streams. These soils have formed in fine-textured lacustrine and alluvial sediment. The native vegetation was tall prairie grasses and salt-tolerant grasses.

In a typical profile, the surface layer is gray silty clay about 3 inches thick. The subsoil is dark-gray clay about 25 inches thick. Just beneath the subsoil is a layer of olive-gray and olive clay about 7 inches thick. Underlying this layer is a layer that contains a large amount of lime. This layer is olive and pale-olive, mottled, very strongly calcareous clay in the upper part and is pale-olive, mottled, strongly calcareous silty clay in the lower part. It extends to a depth of 60 inches or more.

These soils have slow permeability and high available water capacity. A seasonal high water table is within 3 to 5 feet of the soil surface.

Typical profile of a Ryan silty clay (200 feet west and 50 feet south of the northeast corner of the NW¼ of sec. 9, T. 155 N., R. 52 W.):

A1—0 to 3 inches, gray (N 5/0) silty clay, black (5Y 2/1) when moist; weak, very fine, angular blocky structure; extremely hard when dry, sticky and very plastic when wet; abrupt, smooth boundary.

B21t—3 to 10 inches, dark-gray (N 4/0) clay, black (5Y 2/1) when moist; strong, coarse, prismatic structure breaking to strong, fine, angular blocky structure; extremely hard when dry, very firm when moist, sticky and very plastic when wet; gradual, wavy boundary.

B22t—10 to 23 inches, dark-gray (N 4/0) clay, black (5Y 2/2) when moist; moderate, medium, prismatic structure breaking to moderate, very fine, angular blocky structure; extremely hard when dry, very firm when moist, sticky and very plastic when wet.

B3—23 to 28 inches, dark-gray (N 4/0) clay, dark olive gray (5Y 3/2) when moist; moderate, very fine, angular blocky structure; extremely hard when dry, very firm when moist, sticky and very plastic when wet.

C1—28 to 35 inches, olive-gray (5Y 5/2) and olive (5Y 5/3) clay, olive (5Y 4/3) when moist; massive; extremely hard when dry, very firm when moist, sticky and very plastic when wet.

C2ca—35 to 41 inches, olive (5Y 5/3) and pale-olive (5Y 6/3) clay, olive (5Y 5/3) when moist; a few, fine, distinct, yellow mottles and common, fine, faint, very dark gray (5Y 3/1) mottles and a few, fine, distinct, yellowish-brown (10YR 5/6) mottles when moist; massive; very firm when moist, sticky and very plastic when wet; very strongly calcareous.

C3ca—41 to 60 inches, pale-olive (5Y 6/3) silty clay, olive (5Y 5/3) when moist; many, fine, distinct, brownish-yellow and strong-brown mottles and common, fine, faint, very dark gray and yellowish-brown mottles when moist; massive; extremely hard when dry, firm when moist, sticky and plastic when wet; strongly calcareous.

The A horizon is as much as 5 inches thick, but it is about 3 inches thick in most places. Texture of the A horizon is silty clay or clay. In some areas the profile contains a thin, gray, friable A2 horizon. The B horizon ranges from 14 to 25 inches in thickness and from olive gray to black, dark gray, or very dark gray in color. The C horizons are clay and silty clay, and they range from dark gray or dark olive gray to olive gray or pale olive in color. In most places these soils are mottled below a depth of 35 inches. The mottles increase in number and in distinctness with increasing depth.

Unlike the Ludden soils, the Ryan soils have a well-defined B horizon.

In Walsh County the Ryan soils were mapped only in a complex with Ludden soils.

Sioux Series

The Sioux series consists of excessively drained soils that have formed in loamy material over stratified gravel and sand. The native vegetation was short, medium, and tall prairie grasses.

In a typical profile, the surface layer is about 8 inches thick and consists of very dark gray gravelly loam in the upper part and of dark-brown loam in the lower part. Just beneath the surface layer is a layer of dark-brown gravelly loam about 7 inches thick. The next layer is dark-brown and strong-brown gravelly coarse sand about 10 inches thick. This layer is underlain by very pale brown and strong-brown coarse sand and gravel that extend to a depth of 60 inches or more.

In the surface layer, permeability is moderate and the available water capacity is moderate. In the layers beneath the surface layer, permeability is rapid and the available water capacity is very low. The average available water capacity is very low. These soils have a very deep water table.

Typical profile of a Sioux gravelly loam (0.2 mile east and 60 feet north of the center of sec. 33, T. 156 N., R. 56 W.):

A11—0 to 5 inches, very dark gray (10YR 3/1) gravelly loam, black (10YR 2/1) when moist; weak, fine, crumb structure; slightly hard when dry, very friable when moist, slightly plastic when wet; high content of organic matter; abrupt, irregular boundary.

A12—5 to 8 inches, dark-brown (10YR 3/3) loam, very dark brown (10YR 2/2) when moist; moderate, fine, prismatic structure breaking to moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, stickly and plastic when wet; contains a few pebbles; abrupt, smooth boundary.

IIC1—8 to 15 inches, dark-brown (7.5YR 3/2 and 4/4) gravelly loam, dark reddish brown (5YR 3/3) when moist; single grain; loose when dry, very friable when moist, slightly plastic when wet; contains a few soft, weathered stones; clear, smooth boundary.

IIC2ca—15 to 25 inches, dark-brown (7.5YR 4/4) and strong-brown (7.5YR 5/6) gravelly coarse sand, dark reddish brown (5YR 3/3) when moist; single grain; loose when dry, very friable when moist; strongly calcareous.

IIC3—25 to 60 inches, very pale brown (10YR 7/3) and strong-brown (7.5YR 5/6) coarse sand and gravel, brown (10YR 7/3) when moist; single grain; loose when dry or moist; slightly calcareous.

The A horizon ranges from 5 to 16 inches in thickness, and in places it is sandy loam. The gravel and sand in the profile were derived primarily from granite, but shale gravel and sand make up from 5 to 15 percent of the C horizons in some areas.

The Sioux soils are shallower over gravel than the Renshaw soils, and they lack the B horizon that is typical of the Renshaw soils. In contrast to the Coe soils, they have predominantly granitic sand and gravel in their C horizons.

Sioux-Renshaw complex (0 to 8 percent slopes) (Sr).—This mapping unit consists mainly of Sioux and Renshaw soils associated in such complex patterns on glacial outwash plains that it was impractical to map them separately. About 60 percent of this mapping unit is Sioux soils, and 40 percent is Renshaw soils. The Sioux soils are generally in convex areas, and the Renshaw soils are in concave areas. The Sioux soils have the profile described as representative of the Sioux series. The Renshaw soils have a profile similar to the one described as representative of the Renshaw series, except that the surface layer is lighter colored and coarser textured. Cultivated areas are moderately eroded in most places, and the surface layer is gravelly loam or cobbly loam in most of those areas. Cobblestones as much as 6 inches in diameter are common.

The chief limitation to use of these soils for crops is droughtiness caused by the shallow root zone and the low available water capacity of the substratum. In addition, these soils are moderately to highly susceptible to soil blowing if they are cultivated. Most areas of these soils have remained in native grass or have been reseeded to tame grasses. (Capability unit VIs–SwG; the Sioux soil is in windbreak site 10, and the Renshaw soil is in windbreak site 6).

Sioux and Renshaw soils, steep (8 to 30 percent slopes) (SsE).—About 65 percent of this mapping unit is Sioux soils, 25 percent is Renshaw soils, and the rest is other associated soils. The soils are on glacial outwash deposits of sand and gravel. The Sioux soils are in convex areas, and they have dominant slopes of 12 to 30 percent. The Renshaw soils are less sloping than the Sioux. Profiles of these soils are similar to the ones described as representative for their respective series, except that the surface layer of the Renshaw soil is thinner and lighter colored.

Included with these soils in mapping were small areas of steep Embden sandy loam and of Arvilla loam. Also included were some small areas of steep Towner fine sandy loam that lie east of Fordville.

Soils of this mapping unit are used mainly for pasture and as wildlife habitat. The chief limitation to their use for crops is droughtiness, caused by the shallow root zone and the low available water capacity. (Capability unit VIs–SwG; the Sioux soil is in windbreak site 10, and the Renshaw soil is in windbreak site 6)

Svea Series

The Svea series consists of deep, loamy, moderately well drained soils that have formed in calcareous glacial till. These soils are on glacial till plains. Their slopes are generally less than 2 percent, but they are greater in some places. The native vegetation was medium and tall prairie grasses.

In a typical profile the surface layer is very dark gray loam about 8 inches thick. The subsoil is clay loam that is about 11 inches thick and is dark gray in the upper part and is grayish brown in the lower part. Just beneath the subsoil is a layer of very strongly calcareous material that is about 20 inches thick and contains a large amount of lime. This layer is white clay loam in the upper part and is pale-yellow loam in the lower part. Underlying this layer of limy material is light yellowish-brown loam that is mottled in the upper part and extends to a depth of 61 inches or more.

Permeability is moderate in the surface layer and the subsoil and moderately slow in the substratum. These soils have high available water capacity. The water table is very deep.

Typical profile of a Svea loam (1,060 feet south and 150 feet east of the northwest corner of sec. 2, T. 157 N., R. 56 W.):

Ap—0 to 5 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; weak, medium, subangular blocky structure breaking to moderate, fine, crumb structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; abrupt, smooth boundary.

A1—5 to 8 inches, very dark gray (10YR 3/1) loam, black (10YR 2/1) when moist; moderate, coarse, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; abrupt, smooth boundary.

B21—8 to 14 inches, dark-gray (10YR 4/1) clay loam, very dark brown (10YR 2/2) when moist; moderate, coarse, prismatic structure; slightly hard when dry, friable when moist, sticky and plastic when wet; patchy clay films on the surfaces of peds; clear boundary.

B22—14 to 19 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure; hard when dry, friable when moist, sticky and plastic when wet; abrupt, smooth boundary.

C1ca—19 to 26 inches, white (2.5Y 8/2) clay loam, pale yellow (2.5Y 7/4) when moist; weak, medium, subangular blocky structure breaking to weak, fine and very fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; clear boundary.

C2ca—26 to 39 inches, pale-yellow (2.5Y 8/4) loam, light yellowish brown (2.5Y 6/4) when moist; weak, coarse, subangular blocky and weak, thick, platy structure; slightly hard when dry, friable when moist, sticky and plastic when wet; very strongly calcareous; clear boundary.

C3—39 to 54 inches, light yellowish-brown (2.5Y 6/4) heavy loam, light olive brown (2.5Y 5/4) when moist; dark reddish-brown and gray mottles; moderate, thick, platy structure; slightly hard when dry, friable when moist, sticky and plastic when wet; strongly calcareous; few nodules of lime; diffuse boundary.

C4—54 to 61 inches, light yellowish-brown (2.5Y 6/4) loam, light olive brown (2.5Y 5/4) when moist; massive; hard when dry, friable when moist, slightly sticky and plastic when wet; calcareous.

Thickness of the solum is generally between 16 and 30 inches, but deeper soil development is common in swales where local alluvium has been deposited over the till. Thickness of the A horizon ranges from 6 to 14 inches. In most places the A horizon is loam, but it is silt loam in some area. The B2 horizon ranges from 6 to 18 inches in thickness, and it is loam in places. In some places there are thin patches of clay films in the B2 horizon but no appreciable buildup of clay. In most places the C horizon contains few to common grayish and brownish mottles. The C1ca horizon contains a layer of gypsum in places, especially in areas where these soils are associated with Hamerly soils. The underlying glacial till is loam or clay loam. Less than 5 percent of the till is weathered shale, except where these soils are associated with Edgeley soils. In those areas from 5 to 25 percent of the till is weathered shale.

The Svea soils have more grayish colors in their solum than the Barnes soils. They have a thicker solum and a lime zone lower in their profile than the Hamerly soils, and unlike the Hamerly soils, they have a B2 horizon. The Svea soils lack the claypan that is typical in the subsoil of the Cresbard and Cavour soils.

Svea-Barnes loams, nearly level (0 to 3 percent slopes) (SuA).—About 50 percent of this mapping unit is Svea loam, 35 percent is Barnes loam, and 15 percent is other soils. The soils are on glacial till plains. The thicker areas of the Svea soil are in concave swales. The Barnes soil and thinner areas of Svea soil are in convex areas. The slopes are short. The profile of the Svea soil is the one described as representative for the Svea series.

Included with these soils in mapping were areas of Tonka silt loam and of Parnell silty clay loam in depressions.

Climate is the chief limitation to use of the soils of this mapping unit for crops. These soils are also slightly susceptible to soil blowing, and water erosion is a slight hazard on the longer slopes. These soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. (Capability unit IIc–6; windbreak site 1)

Svea-Cresbard loams, nearly level (0 to 6 percent slopes) (SvA).—About 45 percent of this mapping unit is Svea loam, 40 percent is Cresbard loam, and the rest is other soils. In most places these soils have slopes of 1 to 2 percent, but the slopes are as steep as 6 percent in some places. These soils are on glacial till plains. The Svea soil occupies the upper slopes, and the Cresbard soil is in shallow swales, on the very gentle lower slopes, and at the head of intermittent drainageways.

Included with these soils in mapping were small areas of Cavour loam, Barnes loam, Hamerly loam, and Tonka silt loam. Also included were small areas of Edgeley soils and of Cresbard soils that have a substratum of bedded shale below a depth of 40 inches. The areas of Edgeley and Cresbard soils are north of Lankin.

The chief limitation to use of the soils of this mapping unit for crops is the claypan subsoil of the Cresbard soil, which limits growth of roots. Both the Svea and Cresbard soils are also slightly susceptible to soil blowing. These soils are suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIIs–P; the Svea soil is in windbreak site 1, and the Cresbard soil is in windbreak site 4)

Tonka Series

The Tonka series consists of deep, poorly drained soils that have formed in loamy local alluvium and in glacial till. These soils are in shallow depressions in interbeach areas and on the till plain. The areas are mostly less than 5 acres in size, and many of them contain less than 1 acre. Water is ponded on the surface during the wettest parts of the year. It is ponded all year when precipitation is above normal. The native vegetation was wetland grasses, reeds, rushes, and sedges.

In a typical profile, the surface layer is very dark gray silt loam about 16 inches thick. The subsurface layer is about 10 inches thick and consists of loam that is dark gray in the upper part and is gray in the lower part. The subsoil is about 16 inches thick. It is clay loam that is dark gray in the upper part and mottled grayish brown in the lower part. The substratum consists of local alluvium that is underlain by glacial till. It is mottled, olive sandy clay in the upper part and is mottled, pale-olive clay loam in the lower part.

Permeability is moderate in the surface layer and the subsurface layer, moderately slow in the subsoil, and moderately slow or slow in the substratum. The available water capacity is high. A seasonal high water table is within 0 to 5 feet of the soil surface.

Typical profile of a Tonka silt loam in a cultivated field (1,200 feet west and 200 feet north of the southeast corner of sec. 27, T. 158 N., R. 59 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) silt loam, black (10YR 2/1) when moist; cloddy, breaking to moderate, medium and fine, granular structure; hard when dry, friable when moist; slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A1—6 to 16 inches, very dark gray (10YR 3/1) silt loan, black (10YR 2/1) when moist; moderate, medium, subangular blocky structure breaking to moderate, fine, subangular blocky structure; slightly hard when dry,

friable when moist, slightly sticky and slightly plastic when wet; abrupt, smooth boundary.

A21—16 to 20 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) when moist; weak, medium, platy structure breaking to weak, very fine, subangular blocky structure; soft when dry, friable when moist, slightly sticky and slightly plastic when wet; abrupt, wavy boundary.

A22—20 to 26 inches, gray (10YR 6/1) loam, very dark brown (10YR 2/2) when moist; weak, medium, platy structure breaking to weak, very fine, subangular blocky structure; soft when dry, friable when moist, plastic and slightly sticky when wet; abrupt boundary.

B2t—26 to 33 inches, dark-gray (10YR 4/1) clay loam, very dark brown (10YR 2/2) when moist, and very dark grayish brown (2.5Y 3/2) if crushed; strong, medium and fine, angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; continuous clay films on the surfaces of peds; clear boundary.

B3tg—33 to 42 inches, grayish-brown (2.5Y 5/2) clay loam, very dark grayish brown (2.5Y 3/2) when moist; many, fine, distinct, dark yellowish-brown mottles; strong, medium and fine, angular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; continuous clay films on the surfaces of peds; contains a few nodules of manganese.

Cg—42 to 54 inches, olive (5Y 5/3) sandy clay, dark grayish brown (2.5Y 4/2) when moist; many, fine, prominent, yellowish-brown mottles; massive; hard when dry, firm when moist, very sticky and very plastic when wet; contains a few fine nodules of iron and manganese.

Texture of the A1 horizon ranges from silt loam to loam or silty clay loam, and texture of the A2 horizon ranges from loam to silt loam or fine sandy loam. The B horizon is dark gray, very dark gray, or grayish brown. It contains few to many mottles that range from gray to brown in color. Texture of the B horizon ranges from sandy clay loam or clay loam to clay. The C horizon is dense and is highly mottled. It is noncalcareous to strongly calcareous and ranges from sandy clay or clay to sandy clay loam or clay loam in texture. Thickness of the local alluvium over glacial till ranges from only a few inches to several feet.

Unlike the Parnell soils, the Tonka soils have a well-defined A2 horizon. They are less well drained than the Svea soils, and they lack the Cca horizon immediately below the A horizon that is typical of the Vallers and Hamerly soils. The Tonka soils are more poorly drained and have thicker A and B horizons than the Cresbard soils.

In Walsh County the Tonka soils were mapped only in an undifferentiated group with Parnell soils.

Towner Series

The Towner series consists of deep, moderately well drained soils of interbeach plains. These soils have formed in material that has a texture of sandy loam and loamy sand and that is underlain by loamy glacial till or lake sediment. The native vegetation was medium and tall prairie grasses.

In a typical profile, the surface layer is about 19 inches thick and consists of very dark gray sandy loam in the upper part and of dark grayish-brown light sandy loam in the lower part. Just beneath the surface layer is a layer of light yellowish-brown loamy sand that is about 12 inches thick. The next layer is light yellowish-brown sandy loam about 2 inches thick. This is underlain by clay loam till or lacustrine sediment that is light yellowish brown to a depth of 42 inches and is light gray and light yellowish brown below that depth. All of the layers below the surface layer are mottled.

Permeability is moderately rapid in the coarse textured and moderately coarse textured upper layers, and it is moderately slow in the loamy lower layers. The available water capacity is moderate. A seasonal high water table rises to within 2½ to 5 feet of the soil surface.

Typical profile of Towner sandy loam, level, that has slopes of 1 percent, located in a cultivated field (one-fourth mile east and 150 feet north of the southwest corner of sec. 32, T. 157 N., R. 55 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam, black (10YR 2/1) when moist; weak, medium and fine, subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky when wet; a few fine pebbles; abrupt, smooth boundary.

A1—6 to 19 inches, dark grayish-brown (10YR 4/2) light sandy loam, very dark grayish brown (10YR 3/2) when moist, and grayish brown (10YR 5/2) if crushed; a few, fine, faint, brown mottles; very weak, coarse, prismatic structure breaking to weak, medium and fine, subangular blocky structure; slightly hard when dry, very friable when moist; a few pebbles; clear, wavy boundary.

C1—19 to 31 inches, light yellowish-brown (2.5Y 6/3) loamy sand, olive brown (2.5Y 4/4) when moist; common, fine, faint, brown and very fine black mottles when moist; single grain; soft when dry, loose when moist; a few fine roots; abrupt, wavy boundary.

C2—31 to 33 inches, light yellowish-brown (2.5Y 6/4) sandy loam, olive brown (2.5Y 4/3) when moist; common, fine, distinct, yellowish-brown mottles; weak, medium and fine, subangular blocky structure; hard when dry, very friable when moist; a few pebbles and stones; calcareous; clear, wavy boundary.

IIC3ca—33 to 42 inches, light yellowish-brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/4) when moist; common, fine and medium, prominent, yellowish-brown and gray mottles; moderate, fine, subangular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; a few stones; strongly calcareous; gradual, wavy boundary.

IIC4—42 to 60 inches, light-gray (5Y 7/1) and light yellowish-brown (2.5Y 6/4) clay loam till; few, fine, prominent, brown (7.5Y 5/4) mottles, many, medium, yellowish-brown (10YR 5/6) mottles, and a few, fine, black mottles; weak, thick, platy and moderate, medium, blocky structure characteristic of till; pebbles and stones at random throughout the horizon; calcareous.

In places the A horizon is fine sandy loam. Texture of the C1 and C2 horizons is loamy sand to sandy loam. Depth to the IIC horizon ranges from 18 to 40 inches. Texture of the IIC horizon ranges from loam or clay loam to silt loam. The number of stones and pebbles in the C and IIC horizons is variable. In places a stone line separates the C and IIC horizons. Piles of stones are a common feature of the landscape.

The Towner soils have coarser textured A and C horizons than the Lankin soils. They have loamy IIC horizons that are lacking in the Embden soils.

Towner sandy loam, level (0 to 3 percent slopes) (ToA).—This is the only soil of the Towner series mapped in the county. It occupies interbeach areas that are dotted by a few depressions in which runoff accumulates. Piles of stones are a common feature of the landscape.

Included with this soil in mapping were some areas of eroded soils that have a lighter colored, slightly coarser textured surface layer than typical for Towner soils. Also included were areas of soils that have a thicker surface layer than normal for Towner soils, as a result of deposition by wind.

The chief limitation to use of this Towner soil for crops is high susceptibility to soil blowing in cultivated areas. This soil is suited to the field crops, hay crops, and pasture

plants commonly grown in the county, however, and most of the acreage is cultivated. (Capability unit IIIe-3M; windbreak site 1)

Ulen Series

The Ulen series consists of deep, moderately well drained and somewhat poorly drained soils that have formed in sandy water-deposited material. The native vegetation was mainly medium and tall prairie grasses.

In a typical profile, the surface layer is about 15 inches thick and consists of black sandy loam in the upper part and is very dark gray fine sandy loam in the lower part. Just beneath the surface layer is a layer of very strongly calcareous loam that is about 17 inches thick and contains a large amount of lime. This layer is light gray in the upper part and is white mottled with light olive brown in the lower part. Beneath the layer in which lime has accumulated is mottled, stratified loamy and sandy sediment that typically is light yellowish-brown loamy fine sand in the upper part, pale-yellow loamy very fine sand and loamy fine sand in the middle part, and white loamy coarse sand in the lower part. This stratified material extends to a depth of 62 inches or more.

Permeability is moderate in the surface layer and in the layer where lime has accumulated, and it is moderately rapid in the layers below. The available water capacity is moderate. A seasonal water table is within 3 to 5 feet of the soil surface.

Typical profile of Ulen sandy loam in a cultivated field (680 feet west and 100 feet north of the southeast corner of sec. 2, T. 156 N., R. 55 W.):

Ap—0 to 8 inches, black (10YR 2/1) sandy loam, black (10YR 2/1) when moist; weak, medium, subangular blocky structure breaking to weak, fine, crumb structure; slightly hard when dry, very friable when moist; slightly calcareous; abrupt, smooth boundary.

A1—8 to 15 inches, very dark gray (10YR 3/1) fine sandy loam, black (10YR 2/1) when moist; moderate, medium, subangular blocky structure; slightly hard when dry, very friable when moist, slightly plastic when wet; slightly calcareous; abrupt, wavy boundary.

C1ca—15 to 25 inches, light-gray (5Y 7/1) loam, gray (5Y 5/1) when moist; moderate, medium, subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; very strongly calcareous; clear, wavy boundary.

C2ca—25 to 32 inches, white (5Y 8/2) loam, light brownish gray (2.5Y 6/2) when moist; common, medium, faint, light olive-brown mottles; moderate, medium, subangular blocky structure; slightly hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; very strongly calcareous; clear, wavy boundary.

C3—32 to 39 inches, light yellowish-brown (10YR 6/4) loamy fine sand, dark brown (10YR 4/3) when moist; common, fine, distinct, dark yellowish-brown and olive mottles; weak, medium, subangular blocky structure; slightly hard when dry, very friable when moist; calcareous; clear boundary.

C4—39 to 51 inches, pale-yellow (2.5Y 7/4) loamy very fine sand, olive brown (2.5Y 4/4) when moist; common, medium, distinct, yellowish-brown and olive-gray mottles; single grain; slightly hard when dry, very friable when moist; calcareous.

C5—51 to 57 inches, pale-yellow (2.5Y 7/4) loamy fine sand, gray (5Y 5/1) and dark yellowish brown (10YR 4/4) when moist; single grain; loose when dry or moist; very friable; calcareous.

C6—57 to 62 inches, white (5Y 8/2) loamy coarse sand, dark gray (5Y 4/1) when moist; a few, medium, prominent, brown mottles; single grain; slightly hard when dry, very friable when moist; slightly calcareous.

The A horizon ranges from 8 to 15 inches in thickness, and it is loam or loamy sand in places. The Cca horizon ranges from 8 to 17 inches in thickness, and it is sandy loam in some places. Mottles in the Cca horizon range from few to common. Texture of the material below the Cca horizon ranges from loamy very fine sand or loamy fine sand to loamy coarse sand, sand, or fine sand. Color of the mottles in the material below the Cca horizon ranges from yellowish brown to white.

The Ulen soils are better drained than the Fossum and Arveson soils. They are coarser textured than the Glyndon and Borup soils, and they are less well drained than the Embden soils. In addition, the Ulen soils lack the B horizon that is typical of the Embden soils.

Ulen sandy loam (0 to 5 percent slopes) (Un).—This soil occupies small areas on sandy plains. It has the profile described as representative of the series.

Included with this soil in mapping were small areas of moderately eroded Ulen soils and small areas of Arveson and Fossum soils. Also included were areas of soils that have a surface layer of sandy loam and that have a substratum of coarse sand or gravel.

This Ulen soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. High susceptibility to soil blowing is the chief limitation to use of this soil for cultivated crops. (Capability unit IIIe-3; windbreak site 1)

Vallers Series

The Vallers series consists of deep, calcareous, poorly drained soils that have formed in glacial till or in loamy local alluvium over glacial till. These soils are adjacent to potholes and other wet, depressed areas. The native vegetation was mainly tall and medium prairie grasses and wetland grasses, but it was tall prairie grasses, wetland grasses, and salt-tolerant grasses on the saline Vallers soil.

In a typical profile, the surface layer is black loam about 6 inches thick. Tongues of material from the surface layer extend downward into the layer below. The layer just below the surface layer is about 19 inches thick, and it contains an accumulation of lime. This limy layer is white and is very strongly calcareous in the upper part, and it is slightly calcareous and is mottled light gray in the lower part. The next layer is about 13 inches thick and consists of mottled, light olive-gray clay loam alluvial material. It is underlain by mottled, pale-yellow alluvial material that extends to a depth of 60 inches or more. Crystals of gypsum and other salts are distributed throughout the soil profile.

Permeability is moderate in the surface layer, moderately slow in the layer where lime has accumulated, and moderately slow or slow in the layers below. The available water capacity is high. A seasonal water table is within 1 to 5 feet of the soil surface.

Typical profile of a Vallers loam (840 feet south and 100 feet west of the northeast corner of sec. 14, T. 156 N., R. 58 W.):

A1—0 to 6 inches, black (10YR 2/1) loam, black (10YR 2/1) when moist; moderate, very fine, crumb structure; very friable when moist; clear, irregular boundary.

C1cag—6 to 15 inches, white (5Y 8/2) clay loam, olive gray (5Y 5/2) when moist; moderate, medium, subangular blocky structure breaking to moderate, very fine, angular blocky structure; firm when moist, sticky and plastic when wet; narrow tongues of soil material

from the A1 horizon extend downward into this horizon; very strongly calcareous; clear boundary.

C2cag—15 to 25 inches, light-gray (5Y 7/2) clay loam, olive gray (5Y 4/2) when moist; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles; moderate, very fine, angular blocky structure; firm when moist, sticky and plastic when wet; common crystals of gypsum; slightly calcareous; clear boundary.

C3g—25 to 38 inches, light olive-gray (5Y 6/2) clay loam, olive gray (5Y 4/2) when moist; many, medium, prominent, yellowish-brown mottles; weak, very fine, angular blocky structure; firm when moist, sticky and plastic when wet; contains a few crystals of gypsum and fragments of shale; slightly calcareous.

C4g—38 to 60 inches, pale-yellow (5Y 7/3) sandy clay, olive (5Y 4/3) when moist; common, fine, prominent, yellowish-brown and gray mottles; very firm when moist, very sticky and very plastic when wet; contains many fragments of shale and crystals of gypsum; slightly calcareous.

The A horizon ranges from loam to clay loam or silty clay loam in texture and from 5 to 14 inches in thickness. Texture of the C horizons is loam, clay loam, sandy clay loam, or sandy clay. In most places from 1 to 10 percent of the A and Cca horizons is pebbles and stones. In some areas the A horizon contains enough stones to interfere with fieldwork. Thickness of the alluvial material over glacial till ranges from a few inches to several feet. In places these soils are nonsaline throughout the profile, and in other places they are strongly saline throughout. The amount of gypsum and other salts throughout the profile is variable.

The Vallers soils are more poorly drained than the Hamerly soils. Unlike the Tonka and Parnell soils, they have a strongly calcareous Cca horizon immediately below the A horizon. In contrast to the Colvin soils, the Vallers soils formed in local alluvium over glacial till.

Vallers loam, saline (0 to 3 percent slopes) (Va).—This soil is on glacial till plains, where it is adjacent to intermittent drainageways, potholes, and other wet areas. The profile is similar to the one described as representative of the series, except that the surface layer has a higher content of soluble salts.

Included with this soil in mapping were small areas of nonsaline Vallers soils and small areas of Parnell and Tonka soils.

This saline soil is chiefly limited in use for crops by its poor natural drainage, salinity, and moderate to high susceptibility to soil blowing. Where this soil is cultivated, all the crops grown are adversely affected by the salts in the root zone. (Capability unit IIIws–4; windbreak site 9)

Vallers-Hamerly loams (0 to 3 percent slopes) (Vh).—This mapping unit is dominantly Vallers and Hamerly soils that occur in such complex patterns that it was impractical to map them separately. About 55 percent of the acreage is Vallers loam, 30 percent is Hamerly loam, and the rest is other soils. These soils are on glacial till plains, where they occupy areas around potholes and other wet places. The Hamerly soil is on convex slopes at a slightly higher elevation than the Vallers soil, and it is better drained than the Vallers soil. The Vallers soil has the profile described as representative of the Vallers series. From 10 to 30 percent of the soil material in the Vallers profile is moderately saline.

Included with these soils in mapping were small areas of Vallers clay loam, and small areas of Parnell and Tonka soils in depressions.

The chief limitations to use of the soils of this mapping unit for crops are the poor natural drainage of the Vallers soil and the moderate to high susceptibility to soil blowing of both soils. These soils are suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage is cultivated. (Capability unit IIw–4L; the Vallers soil is in windbreak site 9, and the Hamerly soil is in windbreak site 1)

Vallers-Hamerly stony loams (0 to 3 percent slopes) (Vm).—About 55 percent of this mapping unit is Vallers stony loam, 30 percent is Hamerly stony loam, and the rest is other soils. These soils are on glacial till plains, where they are adjacent to potholes and other wet areas. The Hamerly soil occupies convex slopes at a slightly higher elevation than the Vallers soil, and it is better drained than the Vallers soil. Profiles of these soils are similar to the ones described as representative of their respective series, except that from 3 to 15 percent of the soil surface is covered with stones and boulders that make cultivation impractical.

The chief limitations to use of these soils for crops are the poor drainage of the Vallers soil and the numerous stones and boulders that interfere with fieldwork on both soils. Most areas have remained in native grass. (Capability unit Vsw–Sb; windbreak site 10)

Vang Series

The Vang series consists of well-drained soils that have formed in loamy material over shaly sand and shaly gravel. These soils are on glacial outwash plains and terraces. The native vegetation was mainly medium and tall prairie grasses.

In a typical profile, the surface layer is dark-gray loam about 8 inches thick. The subsoil is gray loam about 12 inches thick. The substratum is gray throughout and consists of stratified gravelly material. Typically, it is gravelly loam in the upper part, gravelly loam and gravelly coarse sand in the middle part, and gravelly loamy sand in the lower part. The substratum extends to a depth of 60 inches or more.

These soils have moderate permeability and high available water capacity in the solum and in the upper part of the substratum, and they have moderately rapid permeability and very low available water capacity in the lower part of the substratum. The average available water capacity is moderate. These soils have a very deep water table.

Typical profile of a Vang loam (0.3 mile south of the northwest corner of sec. 24, T. 155 N., R. 57 W.):

A1—0 to 8 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) when moist; moderate, fine, granular structure; very friable when moist, slightly sticky and slightly plastic when wet; clear, smooth boundary. (Abundant broken pebbles of shale are scattered over the soil surface.)

B2—8 to 20 inches, gray (10YR 5/1) loam, very dark gray (10YR 3/1) when moist; weak, medium and coarse, prismatic structure separating easily to moderate fine and medium blocks; friable when moist, slightly sticky and slightly plastic when wet; clear, smooth boundary.

C1—20 to 30 inches, gray (10YR 6/1) gravelly loam, dark gray (10YR 4/1) when moist; massive; very friable when moist; abrupt, wavy boundary.

IIC2—30 to 48 inches, gray (10YR 5/1) gravelly loam and gravelly coarse sand, very dark grayish brown (10YR 3/2) when moist; single grain; loose when dry or moist; slightly calcareous; abrupt, smooth boundary.

IIC3—48 to 60 inches, gray (10YR 5/1) gravelly loamy sand, very dark grayish brown (10YR 3/2) when moist; single grain; loose when dry or moist; slightly calcareous.

The A horizon ranges from 5 to 8 inches in thickness. Shale pebbles and chips of broken shale pebbles are common on and in the A horizon. The B horizon ranges from 12 to 25 inches in thickness, and it is clay loam in places. Thickness of the solum over shale gravel and shale sand ranges from 20 to 40 inches. The C horizons are predominantly shale gravel and coarse shale sand, but from 25 to 40 percent of these horizons is crystalline gravel and sand. In most places the A and B horizons are noncalcareous, but the C horizons are generally slightly calcareous, and they contain fine masses of lime.

The Vang soils are deeper over gravel than the Brantford and Renshaw soils.

Vang-Brantford loams, nearly level (0 to 3 percent slopes) (VnA).—About 55 percent of this mapping unit is Vang loam, and 45 percent is Brantford loam. These soils are on glacial outwash plains and terraces. The Vang soil is in the concave lower areas, and the Brantford soil occupies the convex higher areas.

Included with these soils in mapping were small areas of moderately eroded soils in which the surface layer is thinner than typical for the soils of this mapping unit. In most places these included soils have more sand and pebble-sized fragments of shale concentrated on their surface than typical for the soils of this mapping unit.

The chief limitations to use of the soils for crops are droughtiness as a result of the shallow to moderately deep root zone and the low available water capacity of the substratum, and, in addition, the moderate susceptibility of the soils to soil blowing. These soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and most of the acreage is cultivated. (Capability unit IIIs-5; the Vang soil is in windbreak site 3, and the Brantford soil is in windbreak site 6)

Wahpeton Series

The Wahpeton series consists of deep, moderately well drained soils that have formed in recent alluvium. These soils are on natural levees and on high bottom lands along the Red River. The native vegetation was mainly deciduous trees, shrubs, and tall prairie grasses.

In a typical profile, the surface layer is very dark gray silty clay about 7 inches thick. Just beneath the surface layer is a series of layers of dark gray and very dark gray silty clay that are the surface layers of buried soils. Total thickness of these buried layers is about 53 inches.

Permeability is moderate to moderately slow, and the available water capacity is very high. Except when these soils are flooded, the water table is very deep.

Typical profile of Wahpeton silty clay in a cultivated area (160 feet east and 10 feet south of the northwest corner of sec. 18, T. 158 N., R. 50 W.):

Ap—0 to 7 inches, very dark gray (2.5Y 3/1) silty clay, black (10YR 2/1) when moist; cloddy, breaking to strong, very fine, subangular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; abrupt, smooth boundary.

A11—7 to 15 inches, dark-gray (5Y 4/1) silty clay, black (5Y 2/1) when moist; medium prismatic and blocky structure breaking easily to strong, very fine, subangular blocky structure; very hard when dry, firm when moist, very sticky and very plastic when wet; clear boundary.

A12—15 to 28 inches, dark-gray (5Y 4/1) silty clay, black (5Y 2/2) when moist; weak, medium, prismatic structure breaking to strong, very fine, subangular blocky structure; hard when dry, firm when moist, very sticky and very plastic when wet; clear boundary.

A13—28 to 42 inches, dark-gray (5Y 4/1) silty clay, black (5Y 2/1) when moist; moderate, medium, subangular blocky structure breaking to strong, very fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; clear boundary.

A14—42 to 60 inches, very dark gray (5Y 3/1) silty clay, black (5Y 2/1) when moist; strong, very fine, subangular blocky structure; very hard when dry, very firm when moist, very sticky and very plastic when wet.

The Ap horizon is dark gray in some places, and it ranges from 7 to 15 inches in thickness. In some areas the Ap horizon is clay. The buried A horizons range from 23 to 53 inches in combined thickness, and from black or very dark gray to dark olive gray or very dark grayish brown in color. In places the buried layers in the lower part of the profile are slightly limy. In other areas these soils are underlain by a substratum that contains IIC horizons of olive and olive-brown, calcareous, massive, stratified silty clay in the lower part, above a depth of 60 inches.

Wahpeton soils are better drained than the Fargo and Cashel soils.

Wahpeton silty clay (0 to 5 percent slopes) (Wa).—This is the only soil of the Wahpeton series mapped in Walsh County. It is on natural levees and high bottom lands. The areas on natural levees have gentle, convex slopes that on one side of the levee lead to a river and on the other side lead to the glacial lake plain. Flooding is a hazard for short periods in spring when runoff is extensive. Areas of this soil at the lower elevations are especially susceptible to flooding. This soil dries out quickly enough that it can be cultivated shortly after the floodwaters recede.

This soil is moderately to highly susceptible to soil blowing. In most places it is suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. (Capability unit IIe-4; windbreak site 1)

Walsh Series

The Walsh series consists of deep, well drained and moderately well drained soils that have formed in shaly alluvium. These soils are on alluvial valley floors, on terraces, on the foot slopes of coulees, and on alluvial fans. The native vegetation was medium and tall prairie grasses and deciduous trees.

In a typical profile, the surface layer is very dark gray silt loam about 10 inches thick. The subsoil is gray silty clay loam about 12 inches thick. The substratum is shaly alluvium that is gray silty clay loam in the upper part, light brownish-gray silty clay loam between depths of 40 and 48 inches, and gray loam below a depth of 48 inches.

Permeability is moderate in the surface layer, and it is moderately slow in the subsoil and the substratum. The available water capacity is high, and the water table is very deep.

Typical profile of Walsh silt loam in a cultivated field (140 feet east and 350 feet north of the southwest corner of the SE¼ of sec. 21, T. 157 N., R. 56 W.):

A1—0 to 10 inches, very dark gray (10R 3/1) silt loam, black (10YR 2/1) when moist; moderate, very fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; clear, wavy boundary.

B21—10 to 17 inches, gray (10YR 5/1) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, prismatic structure breaking to moderate, fine, prismatic and moderate, very fine, angular blocky structure; hard when dry, friable when moist,

sticky and plastic when wet; very dark brown (10YR 2/2) clay films on the surfaces of peds; gradual, smooth boundary.

B22—17 to 22 inches, gray (2.5Y 5/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; weak, coarse, prismatic structure breaking easily to moderate, very fine, angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; patchy clay films on the surfaces of peds; gradual boundary.

C1—22 to 40 inches, gray (2.5Y 5/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; gradual boundary.

C2—40 to 48 inches, light brownish-gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; a few, fine, faint, brown mottles; moderate, very fine, subangular blocky structure; contains a few fine nodules of lime; gradual boundary.

C3—48 to 60 inches, gray (2.5Y 6/1) loam, very dark gray (2.5Y 3/1) when moist; hard when dry, friable when moist, sticky and plastic when wet; contains a few fine nodules of lime; about 5 percent of horizon, by volume, is shale sand and gravel.

The A horizon ranges from 6 to 15 inches in thickness and from loam to silty clay loam in texture. The B horizon ranges from gray or dark gray to brown in color, from 10 to 30 inches in thickness, and from silty clay loam to loam in texture. In places the C horizons are clay loam or loam to a depth of 40 inches. A large part of the profile is silt and fine particles of shale the size of grains of sand. In some places the profile contains shaly gravel and sand between depths of 40 and 60 inches. In most places the solum is noncalcareous but the substratum contains a slight or moderate amount of segregated lime in nests or nodules. In a few places, however, the profile is calcareous between depths of 36 and 60 inches. The profile contains the surface layer of a buried soil in some places.

The Walsh soils are finer textured than the Brantford and Renshaw soils, and they lack the gravelly substratum at a moderate depth that is typical of the Brantford and Renshaw soils. They contain more fine shaly material than the Overly soils, and they lack the Cca horizon that is common of the Overly soils. The Walsh soils have formed in older alluvium than the LaPrairie soils, and they have more distinct horizons and greater structural development in their profile than the LaPrairie soils. They lack the substratum of shaly till and bedded shale that underlies the Edgeley soils. The Walsh soils have a thicker solum than the Kloten soils. They lack the substratum of bedded shale that is typical of the Kloten soils, and they lack the substratum of shaly gravel that is typical of the Vang soils.

Walsh loam, sloping (3 to 9 percent slopes) (WhC).—This soil has formed in shaly alluvium that has washed or fallen from the steep sides of valleys and has formed alluvial foot slopes and fans. The profile is similar to the one described as representative of the series, except that the surface layer is loam and the content of shaly sand and shaly gravel is greater in all horizons.

Included with this soil in mapping were small areas of Edgeley loam.

The chief limitation to use of this Walsh soil for crops is susceptibility to water erosion, but this soil is also moderately susceptible to soil blowing. Nevertheless, it is suited to the field crops, hay crops, and pasture plants commonly grown in the county. Most of the acreage is under cultivation and is used for small grains, tame hay, and pasture. (Capability unit IIIe-6; windbreak site 1)

Walsh loam, sand substratum, nearly level (0 to 3 percent slopes) (WlA).—This soil is on glacial outwash terraces. It has formed in deep, loamy alluvium derived from shale that is underlain by shaly sand and gravel. This soil has a profile similar to the one described as representative of the series, except that the surface layer is loam, the substratum contains coarse shaly sand and shaly gravel, and there is more sand and gravel throughout.

Climate is the chief limitation to use of this soil for crops. This soil is also slightly susceptible to soil blowing, but it is suited to the commonly grown field crops, hay crops, and pasture plants. Most of the acreage is cultivated. (Capability unit IIc-6; windbreak site 1)

Walsh loam, sand substratum, gently sloping (3 to 6 percent slopes) (WlB).—This soil is on terraces and on the side slopes of intermittent drainageways. It has formed in loamy alluvium over shaly gravel and shaly sand. The profile is similar to the one described as representative of the series, except that it has a loam surface layer and has coarse shaly sand and shaly gravel in the substratum.

Included with this soil in mapping were small areas of Brantford loam and small areas that are moderately eroded.

This Walsh soil is moderately susceptible to soil blowing, but it is suited to the commonly grown field crops, hay crops, and pasture plants. Most of the acreage is cultivated. (Capability unit IIe-6; windbreak site 1)

Walsh silt loam (0 to 3 percent slopes) (Wm).—This soil has formed in deposits of shaly alluvium on valley floors, alluvial fans, and natural levees. It has the profile described as representative of the series.

Climate is the chief limitation to use of this soil for crops. This soil is also slightly susceptible to soil blowing, but it is suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Most of the acreage is cultivated. (Capability unit IIc-6; windbreak site 1)

Walsh clay loam, level (0 to 3 percent slopes) (WnA).—This soil is on alluvial valley floors and on alluvial fans. It has a profile similar to the one described as representative of the series, except that the surface layer is clay loam.

Included with this soil in mapping were some areas of Walsh silt loam.

Moderate to high susceptibility to soil blowing is the chief limitation to use of this soil for crops. This soil is suited to the field crops, hay crops, and pasture plants commonly grown in the county, however, and nearly all of the acreage is cultivated. (Capability unit IIe-4; windbreak site 1)

Waukon Series

The Waukon series consists of deep, moderately well drained and well drained soils that have formed in calcareous glacial till. The native vegetation was mixed hardwoods.

In a typical profile, the surface layer is dark-gray loam about 10 inches thick, and the subsurface layer is grayish-brown loam about 6 inches thick. The subsoil is light olive-brown clay loam that is about 10 inches thick. The upper part of the substratum is pale-olive clay loam that extends to a depth of about 37 inches. The middle part of the substratum, between depths of 37 and 44 inches, is pale-yellow, calcareous clay loam. The lower part is pale-yellow, strongly calcareous loam that extends to a depth of 60 inches or more.

Permeability is moderate in the surface layer and the subsurface layer, and it is moderately slow in the subsoil

and the substratum. The available water capacity is high, and the water table is very deep.

Typical profile of a Waukon loam (1,100 feet north of the southwest corner of the NW¼ of sec. 11, T. 158 N., R. 57 W.):

A1—0 to 10 inches, dark-gray (10YR 4/1) loam, black (10YR 2/1) when moist; moderate, fine, crumb structure breaking to moderate, very fine, crumb structure; soft when dry, friable when moist, slightly sticky and plastic when wet; clear, wavy boundary.

A2—10 to 16 inches, grayish-brown (2.5Y 5/2) loam, dark yellowish brown (10YR 3/4) when moist; moderate, fine, angular blocky structure breaking to moderate, very fine, angular blocky structure; soft when dry, very friable when moist, slightly sticky and plastic when wet; clear, wavy boundary.

B2t—16 to 26 inches, light olive-brown (2.5Y 5/4) clay loam, very dark grayish brown (10YR 3/2) when moist; peds have a dark grayish brown (2.5Y 4/2) coating when dry and a very dark grayish brown (2.5Y 3/2) coating when moist; moderate, medium, prismatic structure breaking to moderate, medium and fine, angular blocky structure; very hard when dry, firm when moist, very sticky and plastic when wet; clear, irregular boundary.

C1—26 to 37 inches pale-olive (5Y 6/3) clay loam, olive (5Y 4/3) when moist; a few, fine, faint mottles; moderate, medium, subangular blocky structure breaking to moderate, fine, subangular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; clear boundary.

C2—37 to 44 inches, pale-yellow (5Y 7/4) clay loam, dark grayish brown (2.5Y 4/2) when moist; a few, fine, distinct mottles; moderate, fine, subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; calcareous.

C3ca—44 to 60 inches, pale-yellow (5Y 7/3) loam, dark grayish brown (2.5Y 4/2) when moist; a few, fine and medium, distinct, yellowish-brown mottles; massive; hard when dry, slightly sticky and slightly plastic when wet; strongly calcareous.

The Waukon soils in Walsh County have a thicker A horizon than typical for the Waukon series. In places the A1 horizon is silt loam. The A2 horizon is mixed with the material in the plow layer in most cultivated fields. Texture of the B2t horizon ranges from loam or clay loam to sandy clay loam, and the color of that horizon ranges from dark grayish brown to light olive brown or dark brown. The B2t horizon has patchy to continuous clay films on the surfaces of the peds. Depth to the layer in which lime has accumulated ranges from 19 to 44 inches. From 5 to 20 percent of the C horizon is fragments of shale.

The Waukon soils have more clay in their B horizon than the Barnes and Edgeley soils. Unlike the Barnes and Edgeley soils, they have a discontinuous A2 horizon.

Waukon loam, gently undulating (1 to 5 percent slopes) (WoB).—This soil occupies small areas on uplands underlain by glacial till. Piles of stones, resulting from surface clearing, are a part of the landscape. A profile of this soil is described as representative of the series. In cultivated areas the surface layer is thinner and lighter colored than the one in the profile described as representative.

Included with this soil in mapping were small areas of Barnes loam and of Edgeley loam.

Water erosion is the chief limitation to use of this soil for crops that require cultivation, and this soil is also slightly susceptible to soil blowing. It is suited to the commonly grown field crops, hay crops, and pasture plants, however, and most of the acreage has been cleared for cultivation. A few small patches of timber remain. They are used for pasture or are undisturbed and are used as wildlife habitat. (Capability unit IIe-6; windbreak site 1)

Waukon loam, strongly rolling (6 to 10 percent slopes) (WoD).—This soil occupies narrow areas along some of the large drainageways that dissect the till plains. The profile is similar to the one described as representative of the series, except that the surface layer is thinner and the zone of lime accumulation is closer to the surface. In addition, the surface is covered with a layer of leaf litter.

Included with this soil in mapping were small areas of a strongly sloping Buse loam, and small areas of an undulating Edgeley loam.

Water erosion is the chief limitation to use of this soil for crops that require cultivation, and this soil is also slightly susceptible to soil blowing. Most of the acreage is in native timber. Some small areas are included in fields of less sloping soils, and those areas are cultivated. (Capability unit IVe-6; windbreak site 3)

Zell Series

The Zell series consists of deep, well-drained soils that have formed in silty glacial lake sediment. The native vegetation was medium and tall prairie grasses and hardwood trees.

In a typical profile, the surface layer is about 8 inches thick and consists of silt loam that is dark gray and is slightly calcareous in the upper part and is light brownish gray and strongly calcareous in the lower part. Just beneath the surface layer is a layer that is also about 8 inches thick and consists of light-gray, strongly calcareous silt loam that contains a large amount of lime. This limy material is underlain by mottled, stratified silt, silty clay loam, and silty clay. Typically, the uppermost layer of this stratified material is light-gray silt loam about 5 inches thick. The next layer is light-gray, stratified silt and silty clay loam about 15 inches thick. Just beneath this layer is a layer of yellowish-brown and pale-yellow silty clay about 12 inches thick. Below this is light brownish-gray silty clay that extends to a depth of 56 inches or more.

Permeability is moderate in the surface layer, and it is moderately slow or slow below the surface layer. The available water capacity is high, and the water table is very deep.

Typical profile of a Zell silt loam in a cultivated field (860 feet south and 40 feet east of the northwest corner of the NE¼ of sec. 10, T. 157 N., R. 52 W.):

Ap—0 to 5 inches, dark-gray (10YR 4/1) silt loam, black (10YR 2/1) when moist; cloddy, breaking to weak, fine, crumb structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; slightly calcareous; abrupt boundary.

ACca—5 to 8 inches, light brownish-gray (2.5Y 6/2) silt loam, very dark grayish brown (2.5Y 3/2) when moist; weak, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; strongly calcareous; abrupt, wavy boundary.

C1ca—8 to 16 inches, light-gray (2.5Y 7/2) silt loam, olive brown (2.5Y 4/3) when moist; a few, fine, distinct, yellowish-brown mottles when dry; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; strongly calcareous; clear boundary.

C2—16 to 21 inches, light-gray (2.5Y 7/2) silt loam, olive brown (2.5Y 4/3) when moist; a few, fine, distinct, brown mottles; moderate, fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky and slightly plastic when wet; calcareous; contains a few nodules of lime up to 10 millimeters in diameter; clear boundary.

C3—21 to 36 inches, light-gray (2.5Y 7/2), stratified silt and silty clay loam, dark grayish grown (10YR 4/2), grayish brown (2.5Y 5/2), and dark reddish brown (5YR 3/2) when moist; common, medium, prominent, yellowish-brown and yellow mottles; massive; hard when dry, firm when moist, sticky and plastic when wet; slightly calcareous.

C4—36 to 48 inches, light yellowish-brown (2.5Y 6/4) and pale-yellow (2.5Y 7/4) silty clay, strong brown (7.5YR 5/8) and grayish brown (2.5Y 5/2) when moist; massive; hard when dry, firm when moist, sticky and plastic when wet; very slightly calcareous.

C5—48 to 56 inches, light brownish-gray (2.5Y 6/2) silty clay, dark grayish brown (2.5Y 4/2) and strong brown (7.5YR 5/8) when moist; many, medium, prominent, brown mottles; massive; hard when dry, very firm when moist, sticky and plastic when wet.

The A horizon ranges from silt loam to very fine sandy loam or silty clay loam in texture and from 3 to 8 inches in thickness. In places it is very dark gray. Color of the layers below the A horizon ranges from light gray to light yellowish brown or light brownish gray, and color of the mottles ranges from yellow or yellowish brown to brown. The number of mottles increases with increasing depth. In some places the profile has thin layers of moderately fine textured and fine textured sediment in the lower part.

Unlike the Buse soils, the Zell soils have formed in lacustrine sediment. They lack the gravel substratum that is typical in the Coe and Sioux soils, and they lack the B horizon that is typical in the Gardena and Overly soils.

Zell-Gardena silt loams, sloping (6 to 9 percent slopes) (ZgC).—About 60 percent of this mapping unit is Zell silt loam, and 40 percent is Gardena silt loam. These soils are on the side slopes of river valleys that dissect the glacial lake plain. The Zell soil, which is steeper than the Gardena soil, is on the upper parts of the slopes. The Gardena soil is on the lower parts of the slopes.

The chief limitation to use of these soils for crops is their moderate to high susceptibility to water erosion and soil blowing. The soils are suited to the commonly grown field crops, hay crops, and pasture plants, and most of the acreage is cultivated. In most cultivated areas, these soils are slightly to moderately eroded. (Capability unit IVe-4L; the Zell soil is in windbreak site 8, and the Gardena soil is in windbreak site 1)

Zell-Gardena silt loams, steep (9 to 15 percent slopes) (ZgE).—About 50 percent of this mapping unit is Zell silt loam, and the rest is Gardena silt loam. These soils are on the side slopes of river valleys that dissect the glacial lake plain. The Zell soil is steeper than the Gardena soil. It is on the upper parts of the slopes, and the Gardena soil is on the lower parts.

The chief limitation to use of these soils for crops is their moderate to high susceptibility to water erosion and soil blowing, but these soils are also droughty as the result of the rapid runoff. The few areas that are cultivated are moderately to severely eroded. Most of the acreage is in pasture or is used for hay. (Capability unit VIe-Si; the Zell soil is in windbreak site 8, and the Gardena soil is in windbreak site 1)

Use and Management of the Soils

This section describes use and management of the soils of Walsh County for crops and pasture. It also discusses uses of the soils for windbreaks and for wildlife habitat, and it explains uses of the soils for engineering.

Management for Crops and Pasture

Crops commonly grown in this county are hard red spring wheat, durum wheat, barley, flax, sugar beets, potatoes, and alfalfa and other hay crops. In addition, some areas are used for pasture. In the following pages, general practices for managing the soils for these commonly grown crops and pasture are discussed, the system of capability classification is explained, and the capability units are described. Finally, predicted average acre yields of some of the principal crops are given under two levels of management.

General management of cropland

The main considerations in managing cultivated crops in this county are controlling soil blowing and water erosion, conserving moisture in some areas and providing drainage in others, and maintaining soil fertility and good tilth. Practices needed to attain these considerations are described in the following paragraphs.

Controlling soil blowing and water erosion.—Losses of soil through soil blowing and water erosion are serious in some years in Walsh County. The sandy Embden and Hecla soils, and the clayey Fargo and Hegne soils are highly susceptible to soil blowing. If the Fargo and Hegne soils are not protected by a cover of plants or snow, they tend to slake down to sand-size particles that are easily moved by wind.

Water erosion is the main hazard where undulating or steep, loamy soils are cultivated. The risk of water erosion is the greatest during intense rainstorms when the soils are fallowed or lack a protective cover.

Common practices used to control soil blowing and water erosion in dryfarmed areas are wind stripcropping, stubble mulching, growing a cover crop, establishing windbreaks, plowing in spring, and properly managing crop residue. Establishing grassed waterways is an additional practice that helps to protect the soils from water erosion. On some soils only one of these practices provides adequate protection. On others, a combination of several practices is needed.

Wind stripcropping consists of growing crops in strips at angles to the direction of prevailing winds. Prevailing winds in this county are from the north-northwest, and the strips generally run in a north-south or east-west direction. In a conventional stripcropping pattern, strips of crops that protect the soils from blowing are alternated with strips of cultivated row crops or with strips of fallowed soils. Small grains, standing crop residue, and grass or alfalfa are used in the strips established to protect the soils from soil blowing and water erosion. Among those soils for which strips are required are the Bearden, Brantford, and Vang.

Stubble mulching consists of managing plant residue so that protective amounts of residue are left on the surface from the time harvest is completed until the next crop is

seeded. Stubble mulching is an effective practice for controlling soil blowing on soils such as the Embden, Glydon, and Hecla.

In growing a cover crop, a stand of annual plants is established late in summer. These plants protect the soils in fallow fields from soil blowing during winter and spring before the next crop is seeded. The cover crop may consist simply of a volunteer stand of plants that are allowed to grow after the soils are fallowed in summer. Usually, however, a small grain or flax is seeded. The entire field may be seeded to a small grain or flax, or these crops are sometimes seeded in strips that are not more than 1 rod apart in sandy soils, or 3 rods apart on other soils.

A suitable time for planting the cover crop is between the middle of August and the first of September so that growth of the plants will be sufficient to protect the soils from blowing. Usually, a cover crop is not grown following a row crop, because the row crop is harvested too late in fall for a good stand of plants to become established.

Cover crops can be used effectively to control soil blowing and water erosion on nearly all of the soils in the county. On the Barnes and Buse soils that have slopes steeper than 6 percent, the cover crop is seeded on the north-facing and west-facing slopes and on the sides of knolls. In the nearly level and gently undulating areas, the cover crop is seeded at right angles to the prevailing winds.

Field windbreaks are strips or belts of trees and shrubs that are planted as barriers against the prevailing winds. They protect the soils in cultivated fields from soil blowing. Most field windbreaks in this county consist of alternating trees and shrubs in single rows spaced about 40 rods apart in the field. Management of windbreaks is discussed in the subsection "Use of Soils for Windbreaks."

Plowing in spring instead of in fall allows a maximum cover to be maintained on the soils from the time harvest is finished until seeding takes place in spring. It is an effective means of controlling soil blowing on some soils. This practice is suited mainly to such coarse textured or moderately coarse textured soils as the Hecla, Embden, and Ulen. The stubble remains undisturbed in the field between the time the crop is harvested and a new crop is seeded in spring. Then, the soils are plowed, packed, and seeded, all in one operation.

Plowing in spring is not practical for clayey soils or for soils that have formed in glacial till. These soils are sticky when wet, and they seldom dry out early enough to be plowed in spring. Therefore, they are generally plowed in fall. Examples of soils that are not suitable for plowing in spring are the loams, clay loams, and clays of the Svea, Barnes, Fargo, Hegne, Walsh, and Bearden series.

If properly managed, crop residue effectively protects the soils from soil blowing and water erosion. Where crop residue is left standing in the field over winter, it also traps drifting snow, which adds to the supply of moisture as it melts.

Conserving moisture and providing drainage.—In dry-farmed areas conserving moisture generally means reducing evaporation, limiting runoff, increasing infiltration, and controlling weeds. Among the effective measures for conserving moisture are stubble mulching, stripcropping, establishing field windbreaks, properly managing crop residue, and applying fertilizer. In addition, summer fallowing helps to control weeds and to build up the content of moisture. Several of these practices that not only conserve moisture but that also protect the soils from soil blowing and water erosion are described in the preceding paragraphs.

Summer fallowing is the practice of leaving a soil idle for one cropping period but cultivating as many times as necessary to eliminate weeds and to save moisture. Fallowing conserves about 20 percent of the moisture that falls during the fallow period. Sometimes a row crop is included in the cropping system instead of summer fallowing. Less moisture is conserved when this is done, but yields of the crop that follow are only slightly lower than when the soil is summer fallowed.

Wet soils are generally drained artificially if they can be used for crops and if drainage is feasible. Among those soils that are most commonly drained in this county are the Borup, Colvin, Fargo, and Grano soils of the lake plain. In addition, some areas of Tonka and Parnell soils in small depressions on the till plain and on interbeach plains are drained. Water from surrounding areas runs into the depressions in which the Tonka and Parnell soils occur, and many of these depressions have no natural outlets. In many of these depressions, the soils dry out early enough that they can be tilled early in spring, when the adjacent, better drained soils are ready for tillage. Tillage has to be delayed for other soils, and some soils cannot be tilled at all. Thus, these depressions cause inconvenience and extra work, as well as some loss of production.

In many of the depressions, the soils can be drained artificially by digging ditches so that the water from two or more depressions is combined into one. These drains are back sloped so that they can be crossed with farm machinery. The cost of the drains and the availability of outlets determine whether artificial drainage will be practical.

Maintaining soil fertility and good tilth.—A good cropping system aids in maintaining an adequate supply of nitrogen and organic matter in the soils. It also improves the quality of the crops; helps to control weeds, insects and diseases; keeps the soil in good tilth; and makes the most efficient use of labor, machinery, and other resources. The cropping system should be planned to cover a long period, but the system can be flexible. Substituting one small grain for another or making other substitutions, for example, will not defeat the purpose of the system. An example of a good cropping system is summer fallow followed by a row crop and a small grain. The specified fertilizer is applied for the crop, weeds are controlled, and a green-manure crop is plowed under the year the soil is summer fallowed.

To help in planning a cropping system, crops have been classified as soil building, soil conserving, and soil depleting. Soil-building crops are those that produce a temporary increase in the content of organic matter and nitrogen. Legumes and legume-grass mixtures are examples of these crops. Soil-conserving crops, such as small grains, legumes, and grasses, protect the soils from erosion, and they maintain the content of nitrogen and organic matter at a reasonably high level. Soil-depleting crops, for example potatoes, sugar beets, and other clean-cultivated crops, remove the plant nutrients and organic matter from the soils, and they expose the soils to erosion. Nevertheless, cultivation of these soil-depleting crops is beneficial in

that it helps to control weeds. Where the soils are suited to clean-cultivated crops, the cropping system should be balanced so that it includes soil-building and soil-conserving crops, as well as crops that are soil depleting.

The use of commercial fertilizer is widespread throughout this county. Growers of potatoes and sugar beets apply large amounts of fertilizer. Less fertilizer is used on soils of the glacial till plain than on those of the lake plain.

On most of the cultivated soils, response to applications of nitrogen and phosphorus is very good. Response is best to applications of phosphorus on soils that have a high content of lime or that are moderately saline, as for example, the Hamerly, Bearden, Glyndon, Ulen, and Hegne. Crops on the Cresbard and Cavour soils respond best to nitrogen. Response has been slight where potash has been applied. A well-balanced schedule for applying fertilizer is needed for most of the soils and for most crops.

A soil-testing service to determine mainly which soils are deficient in phosphorus was established in 1953 at the North Dakota State University of Agriculture and Applied Science at Fargo. Fertilizer trials have also been conducted by the University—many of them in Walsh County. The results of these tests and of the fertilizer trials indicate that most of the soils in North Dakota are deficient in phosphorus, and that deficiency of nitrogen limits yields on nonfallowed soils. On fallowed soils a phosphate fertilizer is necessary. It should be applied by using a drill or a planter attachment. For native or tame grasses, applications of nitrogen generally produce a large increase in the amount of forage obtained. Information about fertilizer and about testing the soils can be obtained from the county agent, from the local office of the Soil Conservation Service, or from the Soils Department of the North Dakota State University at Fargo.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering (*7*).

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use. (No soils in Walsh County are in class I.)

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife. (No soils in Walsh County are in class VII.)

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-4 or IIIs-5. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit within each subclass.

Management by capability units

In the following pages, each of the capability units in Walsh County is described, and suggestions for the use and management of the soils in each unit are given. All of these units are dryland capability units, for irrigation is

not practiced extensively in this county. The units are not numbered consecutively, because not all of the units in the statewide system are represented in this county. The names of the soil series represented are mentioned in the description of each unit, but this does not mean that all the soils in a given series are in the unit. Embden soils that have a loam surface layer are in capability unit IIe-5, for example, but Embden soils that have a sandy loam surface layer are in capability unit IIIe-3. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units" at the end of this survey.

CAPABILITY UNIT IIc-6

In this capability unit are well drained Barnes and Edgeley soils; moderately well drained Fairdale, LaPrairie, Overly, Svea, and Walsh soils; and somewhat poorly drained Lankin soils. All of these soils are deep, nearly level, and loamy. They have a medium-textured or moderately fine textured surface layer, subsoil, and substratum in most places, but in some areas the substratum of the Overly soils contains thin layers of fine-textured material. In other places the substratum of the Lankin and Svea soils contains layers of sandy loam.

All of these soils, except the Overly, have moderate to moderately slow permeability throughout, but the fine-textured layers in the Overly substratum are slowly permeable. In most of the soils, the water table is very deep. In the Lankin soil, however, the water table is within several inches to 5 feet of the soil surface during wet periods. In some years the Fairdale and LaPrairie soils also have a high water table and are flooded in spring. All of the soils are easily tilled, and most of them can be tilled early in spring. Flooding in spring sometimes delays fieldwork on the Fairdale and LaPrairie soils.

All of the soils have high natural fertility, but applying fertilizer is generally profitable. Response to fertilizer is variable, depending on the kind of crop to be grown and on the history of cropping in the past.

Wheat, barley, flax, sugar beets, and potatoes are the principal crops, but soils of this unit are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Limited precipitation in some years and cold weather that sometimes delays seeding in spring are the chief limitations to use of these soils for crops, but the soils are also slightly susceptible to soil blowing and water erosion. Soil blowing and water erosion can be easily controlled by practicing stripcropping, stubble mulching, or rough tillage, and by growing cover crops, establishing field windbreaks, and planting close-growing crops year after year. It is important that pastures be protected by a good cover of plants at all times.

CAPABILITY UNIT IIe-4

This capability unit consists of deep, nearly level and gently sloping Cashel, Fargo, Hegne, Overly, Wahpeton, and Walsh soils. These soils are moderately well drained to poorly drained. They have a surface layer of silty clay or clay loam. The surface layer is underlain by the subsoil or by a layer that contains a large amount of lime and that has a texture of silty clay or silty clay loam. The substratum is also silty clay or silty clay loam.

Permeability is moderate to slow, and the available water capacity is high or very high. All of these soils, except the Fargo and the Hegne, have a very deep water table. In the Fargo and Hegne soils, a seasonal high water table rises to the surface or to within 5 feet of the soil surface.

Tillage should be done only when the soils have the right content of moisture. The Fargo, Hegne, and Overly soils are hard when dry and very sticky and very plastic when wet. If these soils are tilled when dry, large, hard clods are turned up, and they leave the surface rough. As a result, additional tillage is required for preparing the seedbed. If the Fargo, Hegne, and Overly soils are tilled when wet, the structure of the surface layer deteriorates and the surface layer tends to puddle. Then, when this layer dries, the soil is nearly impermeable to water and seedlings cannot emerge. A period of freezing and thawing is necessary to restore the permeability of the surface layer and to make this layer again suitable for planting.

In some years all of the soils of this unit remain wet in spring because of their medium to slow surface drainage. In those years seeding is delayed. Some areas of Cashel, Fargo, Hegne, Overly, and Wahpeton soils are subject to flooding in spring.

The soils have a high content of organic matter, but their normally high natural fertility has been reduced by continuous cropping over long periods. For this reason, applying fertilizer is generally profitable. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, sugar beets, and potatoes are the main crops, but these soils are suited to all the commonly grown field crops, hay crops, and pasture plants. They are moderately to highly susceptible to soil blowing, however, and the Fargo and Hegne soils are also susceptible to water erosion. Soil blowing is the greatest hazard in fields where potatoes or sugar beets have been harvested. Potatoes and sugar beets provide little crop residue that will protect the soils, and they are harvested too late in fall for a winter cover crop to be established. Small grains and other close-growing crops generally provide enough residue to protect the soils from erosion. Commonly used practices that help to control soil blowing and water erosion are stripcropping, stubble mulching, rough tillage, growing cover crops, establishing field windbreaks, and planting close-growing crops year after year. It is important to keep a good cover of plants on the pastures at all times.

CAPABILITY UNIT IIe-4L

This capability unit consists of deep, moderately well drained or somewhat poorly drained Antler, Bearden, Gilby, Glyndon, Hamerly, and Svea soils. Most of these soils are nearly level or gently sloping, but some areas of sloping Bearden soils are on the sides of drainageways that dissect the glacial till plain. The surface layer of these soils is calcareous clay loam, silt loam, silty clay loam, or loam. Just beneath the surface layer is a layer of medium-textured or moderately fine textured, strongly calcareous material in which lime has accumulated. Below this layer of limy material is loamy glacial till or lacustrine sediment.

In all of these soils, except the Svea, the water table is within 1 to 5 feet of the soil surface during the wettest parts of the year. The Svea soils have a very deep water table. All of the soils have high available water capacity. All except the Glyndon soils, which are moderately permeable throughout, have moderate permeability in the

surface layer and the subsoil and have moderately slow or slow permeability in the substratum. Runoff is medium to slow. Except for a few areas of Bearden and Glyndon soils, all of the soils contain many shallow depressions that trap water from runoff.

These soils are easily tilled during the growing season, but the many small, wet depressions interfere with fieldwork and make one or more extra planting dates necessary. The medium to slow runoff and the seasonal high water table combine to make these soils wet for longer periods than where the soils are well drained, and seeding is usually delayed for 1 to 2 weeks in spring. In some areas where outlets are available, drainage has been improved by constructing field drains.

These soils are naturally fertile and have a good supply of organic matter. Response to nitrogen and phosphate fertilizer is variable, however, depending on the kind of soil, the kind of crop to be grown, and the history of cropping in the past. Phosphate is more commonly applied on highly calcareous soils such as these than on soils that are less calcareous.

Wheat, barley, oats, potatoes, sugar beets, and flax are the main crops, but these soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitation to use of the soils for crops is their moderate to high susceptibility to soil blowing, but the sloping soils are also susceptible to water erosion. Practices commonly used to control erosion are stripcropping, stubble mulching, rough tillage, growing cover crops, establishing field windbreaks, and planting close-growing crops year after year. Pastures should have a good cover of plants at all times.

CAPABILITY UNIT IIe-5

This capability unit consists of deep, level to gently sloping Embden and Gardena soils that are moderately well drained. These soils have a surface layer of loam or silt loam, and they have a loamy subsoil. The Embden soil has a sandy substratum, and the Gardena soils have a loamy substratum.

The Embden soil has moderate to moderately rapid permeability in the surface layer and the subsoil, and it has moderately rapid permeability in the substratum. The Gardena soils are moderately permeable throughout. All of these soils have high available water capacity. Because of its lower content of silt and clay, however, the Embden soil is more inclined to be droughty than the Gardena soils. Runoff is slow on the level or nearly level soils, and it is medium on the gently sloping Gardena soil. All of these soils have a very deep water table.

The soils of this unit are easily tilled, and they can be tilled early in spring. Wetness is generally not a hazard to crops, even though runoff is slow in the nearly level areas. Areas of nearly level Gardena soils that are adjacent to poorly drained soils in depressions, however, remain wet for longer periods than the other soils. In some years seeding is delayed because these areas are wet.

These soils have moderately high natural fertility, but response to fertilizer is good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Soils of this unit are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The principal crops are wheat, barley, potatoes, and flax, but sorghum, sunflowers, tame grasses, and legumes are also grown extensively. Moderate susceptibility to soil blowing is the chief limitation to use of these soils for crops, but the gently sloping soils are also susceptible to water erosion during periods of extensive runoff in spring, and during rainstorms. Soils in fields that are summer fallowed are especially susceptible to water erosion. Commonly used practices that help to control soil blowing and water erosion are stripcropping, stubble mulching, rough tillage, growing cover crops, and establishing field windbreaks. Pastures should have a good cover of plants at all times.

CAPABILITY UNIT IIe-6

This capability unit consists of deep, gently undulating or gently sloping, well drained and moderately well drained Barnes. Svea, Edgeley, Fairdale, Overly, Walsh, and Waukon soils, and it also includes a deep, gently sloping, somewhat poorly drained Lankin soil. All of these soils have a loamy surface layer. The Fairdale soils have a surface layer that rests directly on a loamy substratum. The other soils have a loamy subsoil, as well as a loamy substratum.

Permeability is moderate in the surface layer, and it is moderate to slow in the subsoil and the substratum. Runoff is medium, and the available water capacity is very high. All of the soils, except the Lankin, have a very deep water table, but the Lankin soil has a water table within 2 to 5 feet of the soil surface during the wetter parts of the year.

These soils are easily tilled, and in most places a good seedbed is easily prepared. Many small depressions containing these soils remain wet after the other areas have dried out, however, and they interfere with fieldwork. In wet years seeding is sometimes delayed on the Lankin soil because of the high water table. When the amount of runoff is greater than normal in spring, the Fairdale soils are subject to flooding, and this can delay seeding.

All of the soils of this unit, except the Fairdale soil and the eroded Barnes and Svea soils, have a high content of organic matter and plant nutrients. The Fairdale soil and the moderately eroded Barnes and Svea soils have a moderately low content of organic matter, and these Barnes and Svea soils are also low in some plant nutrients. Response to fertilizer is generally good on all of the soils. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, and flax are the main crops, but soils of this capability unit are suited to all the commonly grown field crops, hay crops, and pasture plants. Susceptibility to soil blowing and water erosion is the chief limitation to use of these soils for crops. Soil blowing and water erosion are easily controlled by practicing stripcropping, stubble mulching, or rough tillage, and by growing cover crops and establishing field windbreaks. A good cover of plants should be kept on the pastures at all times.

CAPABILITY UNIT IIw-4

Deep, nearly level, poorly drained Fargo and Ludden soils in shallow depressions are in this capability unit. The Fargo soil has a surface layer, a subsoil, and a substratum of silty clay. The Ludden soil has a surface layer of silty clay that is underlain by lacustrine sediment, also consisting of silty clay, and by the surface layers of buried soils.

Permeability is moderately slow or slow, and the available water capacity is high or very high. Runoff is very slow. A seasonal water table is at the surface or is within 5 feet of the surface during the wettest parts of the year.

Tillage should be done only when the soils have the right content of moisture. These soils are hard when dry, and they are very sticky and very plastic when wet. If they are tilled when dry, large, hard clods are turned up, and these clods leave the surface layer rough. Then, additional tillage is required for preparing the seedbed. If these soils are tilled when wet, the structure of the surface layer deteriorates and this layer tends to puddle. When the surface layer dries, the soils are nearly impermeable to water and seedlings cannot emerge. Because these soils are in depressions, runoff intermittently ponds on their surface. During years when only a small amount of water runs off these soils in spring, field crops can be grown. In other years these soils are left idle or are used for hay. When not cultivated, they interfere with fieldwork on adjacent better drained soils.

These soils have a good supply of organic matter, and normally they have high natural fertility. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the cropping system used in the past.

Harvesting is sometimes delayed in years when a large amount of rain is received during the time harvest is in progress. Wet weather can lower the quality of the crop, or it can be so damaging that the entire crop is lost.

Soils of this unit are suited to all the field crops, hay crops, and pasture plants commonly grown in the county, but wheat, barley, and flax are the main crops. These soils are limited in use for crops, chiefly by poor drainage, but they are also moderately to highly susceptible to soil blowing. Where outlets are available, drainage can be improved by constructing field drains. Practices commonly used to control erosion are stripcropping, stubble mulching, rough tillage, growing cover crops, establishing field windbreaks, and planting close-growing crops year after year. A good cover of plants should be kept on the pastures at all times.

CAPABILITY UNIT IIw-4L

This capability unit consists of deep, nearly level, loamy Hamerly, Bearden, Gilby, and Vallers soils. The Hamerly soil is moderately well drained or somewhat poorly drained; the Bearden and Gilby soils are somewhat poorly drained or poorly drained; and the Vallers soil is poorly drained. These soils have a surface layer of silty clay loam or loam that is underlain by a layer of strongly calcareous silty clay loam or loam in which lime has accumulated. Beneath the limy material, the Hamerly, Gilby, and Vallers soils are underlain by loamy lacustrine sediment or by glacial till. The Bearden soil is underlain by stratified sand and gravel at depths below 40 inches.

The Bearden soil has slow permeability in the soil layers above the sand and gravel, and it has rapid permeability in the sand and gravel. The Gilby soil has moderate permeability above the glacial till substratum, and it has moderately slow permeability in the substratum. The Hamerly and Vallers soils have moderate permeability in the surface layer, and they have moderately slow or slow permeability below the surface layer. For all of the soils, the available water capacity is high and runoff is slow or very slow. The Bearden soil is subject to flooding, and the Gilby soil is in depressions where runoff is ponded. The soils have a water table within 1 to 5 feet of the soil surface during the wettest parts of the year.

Soils of this unit are easily tilled, but they remain wet for long periods in spring because of ponding and the high water table. During years when only a small amount of water runs off the surface in spring, field crops can be grown. In other years these soils are left idle or they are used for hay. Undrained areas interfere with fieldwork on adjacent better drained soils.

These soils have a moderately high content of organic matter and of all the normal available plant nutrients, except phosphorus. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the cropping system used in the past.

Harvesting is sometimes delayed in years when a large amount of rain is received while harvest is in progress. Wet weather can lower the quality of the crop, or it can be so damaging that the entire crop is lost.

When these soils can be cultivated, they are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Wheat, barley, and flax are the main crops. The somewhat poor drainage and the moderate to high susceptibility to soil blowing are the chief limitations to use of these soils for crops. Where outlets are available, drainage can be improved by constructing field drains. Practices commonly used to control soil blowing are stripcropping, stubble mulching, rough tillage, growing cover crops, establishing field windbreaks, and planting close-growing crops year after year. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIw-4L2

In this capability unit are deep, nearly level, poorly drained Arveson and Fossum soils in shallow depressions. These soils have a loam surface layer that is underlain by a layer of calcareous or strongly calcareous, moderately coarse textured material that contains a large amount of lime. Below the limy material is stratified, water-deposited material that is moderately coarse textured and coarse textured in most places but that in places contains strata of medium-textured material.

These soils have moderate permeability and high available water capacity in the surface layer, and they have moderate or moderately rapid permeability and moderate available water capacity below the surface layer. Runoff is very slow. A seasonal water table is at the surface or is within 3 feet of the surface during the wettest parts of the year.

These soils are easily tilled when dry, but the high water table, very slow runoff, and ponding of surface runoff keep them too wet for cultivation for long periods of time. When these soils are too wet for seeding, they are left idle or are used for hay. Undrained areas interfere with fieldwork on adjacent better drained soils.

Soils of this unit have a high content of organic matter, and they are well supplied with most plant nutrients. Nevertheless, response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the cropping system used in the past.

Harvesting is sometimes delayed in years when a large amount of precipitation is received during the time when harvest is in progress. Wet weather can lower the quality of the crop, or it can be so damaging that the entire crop is lost.

When these soils can be cultivated, they are suited to the field crops, hay crops, and pasture plants commonly grown in the county. Most areas have been drained, and the principal crops grown in those areas are wheat, barley, flax, alfalfa, and tame hay. The chief limitations to use of these soils for crops is poor drainage, where drainage has not been provided, and moderate to high susceptibility to soil blowing. In addition, these soils are somewhat droughty in years when little rainfall is received during the growing season. Practices commonly used to control soil blowing are stripcropping, stubble mulching, rough tillage, growing cover crops, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIw-6

This capability unit consists of deep, nearly level, poorly drained and very poorly drained Borup, Colvin, Parnell, Tonka, and Perella soils in shallow depressions. These soils have a surface layer of silt loam or silty clay loam. Just beneath the surface layer is a loamy subsoil or a layer of strongly calcareous, loamy material in which lime has accumulated. Underlying the subsoil or the strongly calcareous material is loamy or clayey lacustrine sediment or glacial till that extends to a depth of 60 inches or more.

Permeability is moderate or moderately slow in the surface layer, in the subsoil, and in the layer where lime has accumulated, and it is moderately slow or slow below these layers. The available water capacity is high or very high. Runoff is very slow. A seasonal water table is at the surface or is within 5 feet of the surface during the wettest parts of the year.

These soils are easily tilled, but because they are in depressions, intermittent ponding occurs as the result of surface runoff. During years when the amount of runoff is small in spring, these soils can be used for the commonly grown crops. In years when the amount of runoff is large, however, seeding is delayed for 1 to 2 weeks. In abnormally wet years, water remains ponded on the soil surface too late in spring for cultivated crops to be planted. Then, these soils are left idle or are used for growing hay. When the soils are too wet for cultivation, they interfere with fieldwork on adjacent better drained soils.

Soils of this unit have very high natural fertility, and they are high in content of organic matter. In areas not cultivated, a mat of partly decomposed vegetation covers the surface.

Harvesting is sometimes delayed in years when a large amount of precipitation is received at the time the crop is ready for harvest. Wet weather can lower the quality of the crop, or it can be so damaging that the entire crop is lost.

When these soils can be cultivated, they are suited to the field crops, hay crops, and pasture plants commonly grown in the county. Wheat, barley, potatoes, and flax are the main crops. Poor or very poor drainage is the chief limitation to use of these soils for crops, but the soils are also slightly susceptible to soil blowing. Where outlets are available, drainage can be improved by constructing field drains. If the soils are properly managed, soil blowing is easily controlled. Practices generally used to control soil blowing are stripcropping, rough tillage, stubble mulching, growing cover crops, establishing field windbreaks, and planting close-growing crops year after year. Maintaining a good cover of plants on the pastures at all times is important.

CAPABILITY UNIT IIwe-4

In this capability unit are deep, nearly level, somewhat poorly drained and poorly drained Bearden, Fargo, Hegne, and Grano soils. The surface layer of these soils is silty clay. Just beneath the surface layer, all the soils, except the Fargo, have a layer of fine-textured, strongly calcareous material in which lime has accumulated. This limy material, in turn, is underlain by fine-textured lacustrine sediment. The Fargo soils have a fine-textured subsoil that is underlain by fine-textured lacustrine sediment.

All of the soils, except the Hegne, have moderately slow or slow permeability in the surface layer, but the Hegne soils have moderate permeability in the surface layer. All of the soils have high or very high available water capacity. Runoff is slow. A seasonal water table is at the surface or is within 5 feet of the surface during the wettest parts of the year.

Tillage should be done only when these soils have the right moisture content. If the soils are tilled when dry, large, hard clods are turned up, and the clods leave the surface rough. Then, additional tillage is required for preparing the seedbed. If these soils are tilled when wet, the structure of the surface layer deteriorates and this layer tends to puddle. When the surface layer dries, the soils are nearly impermeable to water and seedlings cannot emerge. Then, a period of freezing and thawing is necessary to restore the permeability of the surface layer and to make the soil again suitable for use as a seedbed. In many areas seeding is often delayed in spring because of the high water table, slow runoff, and ponding of water from runoff.

Soils of this unit have a high content of organic matter in the surface layer. They have moderately high natural fertility, and response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil and on the history of cropping in the past.

Harvesting is sometimes delayed in years when an abnormally large amount of precipitation is received at the time the crop is ready for harvest. Wet weather can lower the quality of the crop, or it can be so damaging that the entire crop is lost.

The main crops grown on these soils are wheat, barley, sugar beets, potatoes, and flax, but the soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitation to use of the soils for crops is the poor or very poor drainage. Where outlets are available, drainage has been improved in some places by constructing field drains. These soils are also moderately to highly susceptible to soil blowing. Soil blowing is the greatest hazard in fields where potatoes or sugar beets have been harvested. Potatoes and sugar beets provide little crop residue that will protect the soils, and they are harvested too late in fall for a winter cover crop to become established. Small grains and other close-growing crops generally provide enough residue to protect the soils from blowing. Practices commonly used to

protect the soils from blowing are stripcropping, stubble mulching, rough tillage, planting cover crops, establishing field windbreaks, and planting close-growing crops year after year. It is important to maintain a good cover of plants in the pastures at all times.

CAPABILITY UNIT IIIe-3

This capability unit consists of deep, moderately well drained, nearly level to sloping Embden soils and of a moderately well drained or somewhat poorly drained, nearly level and gently sloping Ulen soil. These soils have a surface layer of sandy loam. The surface layer is underlain by a moderately coarse textured subsoil or by a layer of strongly calcareous material in which lime has accumulated. The substratum is coarse textured.

These soils have moderate permeability and high available water capacity in the surface layer, in the subsoil, and in the layer in which lime has accumulated. They have moderate or moderately rapid permeability and low available water capacity in the substratum. Runoff is medium to slow, and the water table is very deep.

These soils are easily tilled. If they are tilled when dry, however, the structure of the surface layer deteriorates and susceptibility to soil blowing is increased. In years when precipitation is below normal, adequate moisture for the germination of seeds and for the growth of crops is lacking because of the low available water capacity of the soils.

Soils of this unit have a moderately low content of organic matter and plant nutrients. Response is usually good to fertilizer. In abnormally dry years, however, the usual benefits derived from applying fertilizer are reduced.

These soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county, but wheat, barley, corn, tame grasses, and alfalfa are the crops generally grown. The chief limitations to use of these soils for crops are their high susceptibility to soil blowing, and droughtiness caused by the low available water capacity of the substratum. Practices commonly used to control soil blowing are stripcropping, stubble mulching, rough tillage, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIIe-3M

This capability unit consists of deep, nearly level Rockwell and Towner soils that are deep and nearly level. The Towner soil is moderately well drained, and the Rockwell soil is poorly drained. These soils have a surface layer of fine sandy loam or sandy loam that is underlain by sandy and loamy sediment. In the Rockwell soil, the layer just beneath the surface layer consists of strongly calcareous material in which lime has accumulated. Glacial till underlies the sandy and loamy sediment at some depth between 18 and 40 inches.

Permeability is moderate in the layers above the glacial till, and it is moderately slow in the glacial till. A seasonal water table is within 1 to 5 feet of the soil surface during the wettest parts of the year. The available water capacity is high. Runoff is slow.

These soils are easily tilled. Wetness is generally not a hazard, except in years when the amount of runoff is abnormally high in spring. Then, seeding can be delayed.

Soils of this unit have a moderate to high content of organic matter and plant nutrients, but response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, flax, alfalfa, and potatoes are the crops generally grown, but these soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The principal limitation to use of these soils for crops is their high susceptibility to soil blowing. Practices commonly used to control soil blowing are stripcropping, stubble mulching, rough tillage, growing cover crops, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIIe-6

This capability unit consists of deep, moderately well drained and well drained Barnes, Edgeley, Walsh, and Overly soils. The Edgeley soil is undulating, but some of the other soils are sloping and others are rolling. The surface layer of these soils is loam or silty clay loam, and the subsoil and the substratum are also loamy. The lower part of the Edgeley substratum contains shale bedrock.

Permeability is moderate in the surface layer of these soils, and it is moderately slow or slow below the surface layer. The available water capacity is high. Runoff is medium, and the water table is deep or very deep.

These soils are easily tilled during the growing season, but many areas contain many small depressions where the soils remain wet after the adjacent soils have dried out. The depressions interfere with fieldwork on the adjacent better drained soils.

The content of organic matter and the natural fertility range from high to moderately low. The least fertile areas are those in which erosion has removed a significant part of the original surface layer. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, and flax are the main crops, but soils of this unit are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Susceptibility to water erosion is the chief limitation to use of these soils for crops, but the soils are also slightly susceptible to soil blowing. In addition, they are somewhat droughty because of the medium rate of runoff. Practices that help to control water erosion and soil blowing are stripcropping, stubble mulching, minimum tillage and rough tillage, growing cover crops, and establishing field windbreaks and grassed waterways. Generally, a combination of two or more practices is needed to control water erosion. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIIes-3

In this capability unit are excessively drained, nearly level and gently sloping Arvilla soils that are shallow to moderately deep over sand and gravel. These soils have a surface layer and a subsoil of sandy loam, and they are underlain by sand and gravel.

In the surface layer and the subsoil, permeability is moderate and the available water capacity is high. Below the subsoil, permeability is rapid and the available water capacity is very low. Surface runoff is slow, and the water table is very deep.

These soils are easily tilled, but the soil structure is weak. If these soils are tilled when dry, the structure of the surface layer deteriorates and the soils become more susceptible to soil blowing.

Soils of this unit have a low to moderate content of organic matter, and they are low to moderate in natural fertility. Response to fertilizer is generally good, but inadequate soil moisture during the growing season is often a limitation to growing crops on these soils. The kinds and amounts of fertilizer to apply depend on the crop to be grown and on the history of cropping in the past.

The main crops are wheat, barley, and flax, but these soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitations to use of these soils for crops are their high susceptibility to soil blowing and droughtiness as a result of the shallow root zone and the very low available water capacity of the substratum. Summer fallow is of questionable value because of the small quantity of water these soils can store. Commonly used practices that help to control soil blowing are stripcropping, stubble mulching, rough tillage, growing cover crops, continuous cropping, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIIes-5

This capability unit consists of deep, well-drained Barnes, Brantford, and Vang soils, and of excessively drained Renshaw soils. These soils range from gently sloping to rolling. They have a loam surface layer and a loamy subsoil. The subsoil of the Barnes soil is underlain by loamy glacial till, but the subsoil of the other soils is underlain by thick beds of sand and gravel. The sand and gravel underlying the Brantford and Renshaw soils is at depths of 14 to 20 inches, and that underlying the Vang soils is at depths of 20 to 40 inches.

The Barnes soil has moderate permeability in the surface layer and the subsoil, and moderately slow permeability in the underlying glacial till. This soil has high available water capacity, a very deep water table, and medium runoff. The Brantford, Vang, and Renshaw soils have moderate permeability and high available water capacity in the surface layer and the subsoil. In the underlying layers of sand and gravel, they have moderately rapid or rapid permeability and low or very low available water capacity. The Brantford, Vang, and Renshaw soils have a very deep water table. Runoff is medium to slow.

All of the soils of this unit are easily tilled. Areas of the Barnes soil contain a few to many depressions, however, and in these depressions the soil remains wet after areas of adjacent better drained soils have dried out. These depressions interfere with fieldwork on the adjacent better drained soils.

The Barnes soil has a high content of organic matter and plant nutrients, and the other soils have a moderate content. Response to fertilizer is generally good, but inadequate moisture during years when rainfall is below normal reduces the usual benefits derived from applying fertilizer. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, flax, alfalfa, and tame grasses are the principal crops, but these soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. The chief limitations to their use for crops are their moderate susceptibility to soil blowing and water erosion, and droughtiness. Droughtiness is caused by the shallow to moderately deep root zone, and by the low or very low available water capacity of the sand and gravel underlying the Vang, Brantford, and Renshaw soils. Commonly used practices that help to control soil blowing and water erosion are stripcropping, rough tillage, stubble mulching, growing cover crops, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IIIs-4L

The only soil in this capability unit is Divide loam, level. The soil is moderately well drained and somewhat poorly drained, and it is moderately deep over gravel and coarse sand. A layer of strongly calcareous clay loam that contains a large amount of lime lies between the loam surface layer and the layer of gravel and sand.

The surface layer and the layer of clay loam are moderately permeable and have high available water capacity. In the sand and gravel, permeability is rapid and the available water capacity is very low. Runoff is slow, and the water table is 3 to 5 feet from the soil surface during wet periods. This soil is easily tilled, but wetness sometimes delays seeding in spring. The root zone is shallow to moderately deep.

The content of organic matter is high, and natural fertility is moderate in most places. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the crop to be grown and on the cropping system used in the past.

Wheat, barley, and flax are the main crops, but this soil is suited to all the other field crops, hay crops, and pasture plants commonly grown in the county. Droughtiness and moderate to high susceptibility to soil blowing are the main limitations to use of the soil for crops. In many years crops are damaged by lack of adequate moisture during the growing season. Practices commonly used to protect this soil from blowing are stripcropping, rough tillage, stubble mulching, growing cover crops, continuous cropping, and establishing field windbreaks.

CAPABILITY UNIT IIIs-5

This capability unit consists of well-drained Vang and Brantford soils and of an excessively drained Renshaw soil that has formed in loamy sediment over thick beds of sand and gravel. These soils are nearly level. They have a loam surface layer and subsoil, and they are underlain by sand and gravel. Depth to sand and gravel ranges from 14 to 20 inches in the Brantford and Renshaw soils, and from 20 to 40 inches in the Vang soil.

In the surface layer and the subsoil, permeability is moderate and the available water capacity is high. In the underlying layers of sand and gravel, permeability is moderately rapid or rapid and the available water capacity is low or very low. The water table is very deep. Runoff is slow.

Soils of this unit are easily tilled. In years when rainfall is below normal at seeding time, inadequate moisture for germination is the chief limiting factor to their use for crops.

These soils have a moderate content of organic matter and plant nutrients. Response to fertilizer is generally

good, but inadequate moisture in years when precipitation is below normal reduces the usual benefits derived from applying fertilizer. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the past history of cropping on these soils.

Wheat, barley, flax, alfalfa, and tame grasses are the main crops, but these soils are suited to all of the field crops, hay crops, and pasture plants commonly grown in the county. These soils are chiefly limited in their use for crops by droughtiness caused by the shallow to moderately deep root zone and by the low available water capacity of the substratum, but they are also moderately susceptible to soil blowing. Practices commonly used to control soil blowing are stripcropping, rough tillage, stubble mulching, growing cover crops, and establishing field windbreaks. It is important that a good cover of plants be maintained on the pastures at all times.

CAPABILITY UNIT IIIs-P

This capability unit consists of deep, nearly level Hamerly, Cresbard, and Svea soils. The Svea and Cresbard soils are moderately well drained, and the Hamerly soils are moderately well drained or somewhat poorly drained All of these soils have a loam surface layer and a loamy substratum. The Svea soil has a clay loam subsoil, however, and the Cresbard soils have a subsoil of dense clay. The Hamerly soil contains a layer of strongly calcareous clay loam, which is just beneath the surface layer, and in this layer lime has accumulated.

The Svea and Hamerly soils have moderate permeability above the substratum and moderately slow permeability in the substratum. The Cresbard soils have moderate permeability in the surface layer, and they have moderately slow permeability in the subsoil and the substratum. All of the soils have high available water capacity and slow runoff. The Svea and Cresbard soils have a very deep water table. The Hamerly soil has a seasonal water table within 2 to 5 feet of the surface during the wettest parts of the year.

Soils of this unit are easily tilled throughout the growing season. Preparation of the seedbed generally is not difficult.

These soils have a moderate content of organic matter and a moderate supply of plant nutrients. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, flax, and alfalfa are the main crops grown, but these soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. All of the crops are adversely affected by the dense clay subsoil of the Cresbard soils, however, and by the salinity of the substratum of those soils. The chief limitations to use of these soils for crops are their moderate to high susceptibility to soil blowing, and the restricted root zone of the Cresbard soils as a result of the clay subsoil. The adverse effects of the restricted root zone are most severe in years when precipitation is below normal. Practices commonly used to control soil blowing on these soils are stripcropping, stubble mulching, and rough tillage. It is important that a cover of plants be maintained on the pastures at all times. Barnyard manure and green-manure crops worked into the Cresbard soils make the subsoil of those soils more permeable. Figure 9 shows a typical profile of the Cresbard soils in this capability unit.

CAPABILITY UNIT IIIwe-3

In this capability unit are deep, moderately well drained and poorly drained, nearly level Arveson, Fossum, Hamar, and Ulen soils in shallow depressions. The Arveson, Fossum, and Ulen soils have a surface layer of fine sandy loam or sandy loam that is underlain by a layer of strongly calcareous, moderately coarse textured material in which

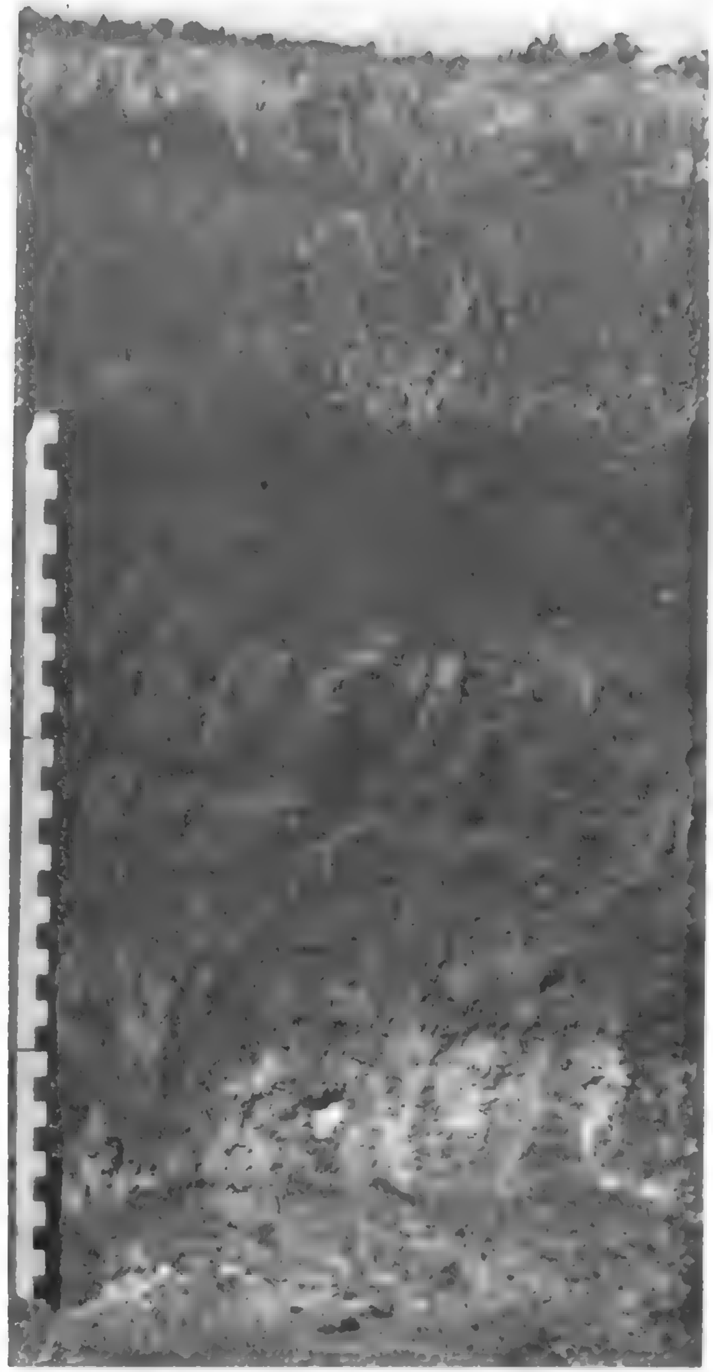

Figure 9.—Profile of a Cresbard loam under native grass.

lime has accumulated. Beneath the limy material is stratified, water-deposited sediment that is mainly moderately coarse textured and coarse textured but that contains strata of medium-textured material in some places. The Hamar soil has a subsoil of loamy sand, and a substratum of medium sand.

These soils have moderate permeability and moderate available water capacity in the surface layer, and they have moderate or moderately rapid permeability and moderate to low available water capacity below the surface layer. A seasonal high water table is at the surface or is within 5 feet of the surface during the wettest parts of the year. Runoff is very slow.

Soils of this unit are easily tilled when dry. Their high water table, very slow runoff, and ponded water on the surface keep them too wet for cultivation for long periods of time. When these soils are too wet to make a suitable seedbed, they are left idle or are used for growing hay. Areas that are not drained interfere with fieldwork on adjacent better drained soils.

These soils contain a large amount of organic matter, and they have a good supply of plant nutrients. Nevertheless, response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Harvesting is sometimes delayed in years when precipitation is above normal at the time the crop is ready for harvest. Wet weather can lower the quality of the crop, or it can be so damaging that the entire crop is lost.

Where these soils have been drained, they are suited to the field crops, hay crops, and pasture plants commonly grown in the county. Wheat, barley, and flax are the main crops. Where the soils have not been drained, seeding is sometimes delayed in spring. Then, barley, flax, or other crops that can be seeded late in spring are grown, or the soils are used for tame grasses. The main limitations to use of these soils for crops are their poor drainage and their high susceptibility to soil blowing. The soils are also somewhat droughty when precipitation is below normal during the growing season. Where outlets are available, drainage can be improved by constructing field drains. Practices commonly used to control soil blowing are stripcropping, stubble mulching, rough tillage, planting cover crops, and establishing field windbreaks. It is important that a good cover of plants be maintained on the pastures at all times.

CAPABILITY UNIT IIIws-4

This capability unit consists of deep, nearly level, moderately saline Bearden, Glyndon, Hegne, Lamoure, and Vallers soils. The Bearden soil is somewhat poorly drained, the Glyndon is moderately well drained or somewhat poorly drained, and the Hegne, Lamoure, and Vallers are poorly drained. All of these soils have a medium-textured, moderately fine textured, or fine textured surface layer. Just beneath the surface layer, all but the Lamoure soils have a strongly calcareous, loamy or clayey layer that contains a large amount of lime, and they have a loamy or clayey substratum. The Lamoure soils lack the strongly calcareous layer, and they are underlain by sand and gravel, in some places at a depth of only 40 inches.

Permeability is moderate to slow, and the available water capacity is high or very high. Runoff is slow or very slow. The water table is 1 to 5 feet from the soil surface during wet periods. Wetness in spring often delays seeding on all the soils. In years when precipitation is above normal during the harvest season, harvesting is sometimes delayed. As a result, the quality of the crop is reduced, and the crop may be lost.

All of the soils, except the Hegne, are easy to till, but the Hegne soil has a fine-textured surface layer and is difficult to till. The Hegne soil is hard when dry, and it is very sticky and plastic when wet. If this soil is tilled when dry, large, hard clods are turned up. These clods make the surface rough, and as a result, additional tillage is required for preparing the seedbed. If the Hegne soil is tilled when wet, the structure of the surface layer deteriorates and this layer tends to puddle. Then, when the surface layer dries out, this soil is nearly impermeable to water and seedlings fail to emerge. Freezing and thawing of the soil will eventually restore the permeability of the surface layer.

Soils of this unit have a moderate to high content of organic matter, but their supplies of phosphorus and available nitrogen are low. Crops generally respond well to applications of a suitable fertilizer, but the usual benefits derived from applying fertilizer are reduced by the salinity of the soils. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the cropping system used in the past.

These soils are suited to all the field crops, hay crops, and pasture plants commonly grown in the county. Wheat, barley, flax, and sugar beets are the main crops. They are adversely affected by the moderate salinity of the soils, but barley and sugar beets are less affected than wheat and flax. Wetness and moderate salinity are the chief limitations to use of these soils for crops, but the soils are also moderately to highly susceptible to soil blowing. Where outlets are available, drainage is improved by constructing field drains. Commonly used practices that help to control soil blowing and water erosion are stripcropping, rough tillage, stubble mulching, growing cover crops, and planting close-growing crops year after year. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IVe-2

Deep, nearly level and gently undulating Hecla, Ulen, and Hamar soils are in this capability unit. The Hecla soils are moderately well drained, the Ulen soil is moderately well drained or somewhat poorly drained, and the Hamar soil is somewhat poorly drained or poorly drained. All of these soils have a surface layer of loamy sand. The Hamar soil has a sandy subsoil that is underlain by a sandy substratum. The Ulen soil has a layer of loamy, strongly calcareous soil material just beneath the surface layer, and in this layer lime has accumulated. A sandy substratum underlies the loamy material. In some places all of these soils contain layers of finer textured material below a depth of 40 inches.

These soils have moderate to moderately rapid permeability throughout. The available water capacity is moderate to low. Runoff is slow. A seasonal water table is at the surface or is within 5 feet of the surface during the wet parts of the year.

Soils of this unit are easily tilled, but the structure of the surface layer lacks durability. If these soils are tilled when dry, the structure deteriorates and susceptibility to soil blowing is increased.

The content of organic matter and the supply of plant nutrients are moderate to low. Cultivated crops generally respond well to fertilizer. In years when rainfall is below normal, however, inadequate moisture during the growing season reduces the usual benefits derived from applying fertilizer. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

These soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county. Wheat, oats, rye, barley, and corn are the principal crops that require cultivation. In addition, some alfalfa and bromegrass are grown, and a few areas are in native grass. Prairie sandreed, Canada wildrye, big bluestem, little bluestem, sand bluestem, and switchgrass are the grasses grown most extensively.

The chief limitation to use of these soils for crops is high susceptibility to soil blowing. These soils are also droughty because of the generally low available water capacity of the substratum. Most areas that have been cultivated are moderately to severely eroded as the result of soil blowing. Drifted soil material has accumulated at the edges of fields and along fence lines and field windbreaks. Practices commonly used to control soil blowing are stripcropping, rough tillage, stubble mulching, growing cover crops, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IVe-4

Hattie silty clay, lacustrine, is the only soil in this capability unit. This soil is deep, sloping, and well drained or moderately well drained. Just beneath the surface layer, it has a layer of strongly calcareous silty clay in which lime has accumulated. The limy material is underlain by stratified loamy and clayey lacustrine sediment.

Permeability is moderately slow in the surface layer and in the layer in which lime has accumulated, and it is slow below these layers. The available water capacity is high or very high. Runoff is medium, and the water table is very deep.

Tilling this soil at the proper moisture content is important. This soil is hard when dry, and it is very sticky and very plastic when wet. If tillage is done when the soil is dry, large, hard clods are turned up, and they leave the surface very rough. As a result, additional tillage is required for preparing the seedbed. If this soil is tilled when wet, its structure deteriorates and the surface layer tends to puddle. Then, when this layer dries, it is nearly impermeable to water and seedlings fail to emerge. Freezing and thawing of the soil will eventually restore the permeability of the surface layer. In some years when rainfall is higher than normal in spring, seeding is delayed.

This soil has a high content of organic matter, and it is high in natural fertility. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of crop to be grown and on the history of cropping in the past.

All of the field crops, hay crops, and pasture plants commonly grown in the county can be grown on this soil, but wheat, barley, flax, and sugar beets are the crops grown most extensively. The dominant plants in areas that have not been cultivated are green needlegrass, porcupinegrass, needle-and-thread, and western wheatgrass. The chief limitation to use of this soil for crops are moderate to high susceptibility to soil blowing and water erosion. Practices that are commonly used to control soil blowing and water erosion are stripcropping, stubble mulching, rough tillage, growing cover crops, and establishing field windbreaks. It is important that a good cover of plants be kept on the pastures at all times.

CAPABILITY UNIT IVe-4L

This capability unit consists of deep, sloping and rolling Buse, Barnes, Zell, and Gardena soils. The Buse soil is excessively drained, the Barnes and Zell soils are well drained, and the Gardena soil is moderately well drained. The Buse and Barnes soils have a surface layer of loam, and the Zell and Gardena soils have a surface layer of silt loam. Just beneath the surface layer, the Buse and Zell soils have a layer of loamy, strongly calcareous material in which lime has accumulated, and they have a loamy substratum. In some places the Barnes and Gardena soils also contain a layer in which lime has accumulated. This layer is between the subsoil and the substratum.

Permeability is moderate in the surface layer, and it is moderate to slow below the surface layer. The available water capacity is high or very high. Runoff is medium. The water table is very deep.

Soils of this unit are easily tilled. Tillage must be across the slope, however, or the susceptibility to water erosion is increased.

These soils have a moderate to moderately low content of organic matter and a moderate to moderately low supply of plant nutrients. Response to fertilizer is generally good. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

These soils are suited to the field crops, hay crops, and pasture plants commonly grown in the county, and most of the acreage is cultivated. Wheat, barley, flax, and alfalfa are the crops most commonly grown. In areas that are not cultivated, the dominant vegetation is mainly little bluestem, big bluestem, green needlegrass, rough fescue, and porcupinegrass. Moderate to high susceptibility to soil blowing and to water erosion are the chief limitations to use of these soils for crops. Practices commonly used to control soil blowing and water erosion are stripcropping, rough tillage, stubble mulching, growing cover crops, and establishing field windbreaks and grassed waterways. It is important that a good cover of grass be maintained on the pastures at all times.

CAPABILITY UNIT IVe-6

This capability unit consists of deep, hilly or strongly rolling Waukon, Buse, and Barnes soils. The Waukon and Barnes soils are well drained, and the Buse soil is excessively drained. The Barnes and Buse soils are eroded. All of these soils have a loam surface layer, and all are underlain by glacial till. The Waukon soil has a loam subsurface layer and a clay loam subsoil, and the Barnes soil has a loamy subsoil. Just beneath the surface layer, the Buse soil has a layer of strongly calcareous loam in which lime has accumulated.

The Buse soil is moderately permeable throughout, but the other soils have moderate permeability in the surface layer, the subsurface layer, and the subsoil, and they have moderately slow permeability below these layers. Runoff

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is rapid. The available water capacity is high or very high, and the water table is very deep.

These soils are easily tilled. If tillage is up and down the slope, however, susceptibility to water erosion is increased.

Soils of this unit have a moderate to low content of organic matter and a moderate to low supply of plant nutrients. Response to fertilizer is generally good. Nevertheless, in years when precipitation is below normal, inadequate moisture during the growing season reduces the benefits usually derived from applying fertilizer. The kinds and amounts of fertilizer to apply depend on the kind of soil, on the crop to be grown, and on the history of cropping in the past.

Wheat, barley, flax, tame grasses, and alfalfa are among the principal crops, but the soils are suited to all the commonly grown field crops, hay crops, and pasture plants. The dominant vegetation in areas of Buse and Barnes soils that have remained in native grass are little bluestem, big bluestem, green needlegrass, and porcupinegrass. On the Waukon soil, the vegetation is mainly a mixture of trees, shrubs, and grasses. Rapid runoff, resulting in droughtiness and susceptibility to water erosion, are the main limitations to use of these soils for crops. The soils are also slightly to moderately susceptible to blowing.

Where these soils are cultivated, water erosion is difficult to control. Practices commonly used to control soil blowing and water erosion are stripcropping, stubble mulching, rough tillage, growing cover crops, and establishing field windbreaks and grassed waterways. It is important that a good cover of plants be maintained on the pastures at all times.

CAPABILITY UNIT Vsw–Sb

In this capability unit are Vallers and Hamerly soils that are deep, nearly level, and stony. The Vallers soil is poorly drained, and the Hamerly soil is moderately well drained or somewhat poorly drained. Both of these soils have a surface layer of stony loam. Just beneath the surface layer, they have a layer of strongly calcareous clay loam in which lime has accumulated. Loamy glacial till underlies the limy material.

These soils have moderate permeability in the surface layer moderate to moderately slow permeability in the layer where lime has accumulated, and moderately slow or slow permeability in the glacial till. They have high available water capacity. Runoff is very slow, and a seasonal water table is within 1 to 5 feet of the surface during the wet parts of the year.

Because of the numerous stones and boulders on the surface, these soils are used only for native pasture and as wildlife habitat. The dominant native vegetation when the pastures are in good condition is big bluestem, little bluestem, switchgrass, prairie cordgrass, prairie dropseed, and Maximillian sunflower. These plants are well suited to use for summer pasture.

It is important that a good cover of plants be maintained on the pastures at all times. If pastures are overgrazed, the more desirable plants are replaced by foxtail barley, spike-sedge, Baltic rush, inland saltgrass, and other less desirable plants. In areas that were formerly farmed and that were later abandoned, quackgrass, bromegrass, and Kentucky bluegrass have been dominant for many years. These grasses are less suitable for grazing in summer than are the native plants when the pastures are in good condition. Areas that formerly were farmed and that were later abandoned can be rapidly returned to native plants by seeding switchgrass, big bluestem, little bluestem, and indiangrass.

The many stones and boulders interfere with fieldwork and limit use of these soils for crops. In most places clearing the areas of stones and boulders is impractical. Where these soils have been cleared and are cultivated, they are moderately to highly susceptible to soil blowing. In addition, the somewhat poor or poor drainage in many areas delays preparation of the seedbed and other fieldwork.

CAPABILITY UNIT Vw–WL

This capability unit consists of poorly drained and very poorly drained, level or nearly level, deep Benoit, Colvin, Grano, Manfred, Parnell, and Rauville soils. The Benoit soil has a surface layer of loam, contains a layer of moderately fine textured, strongly calcareous material in which lime has accumulated, and is underlain by sand and gravel. The Colvin, Grano, Manfred, and Parnell soils have a surface layer of silty clay or silty clay loam. They have a moderately fine textured or fine textured subsoil, or they contain a layer of strongly calcareous material in which lime has accumulated, and they are underlain by medium-textured or fine-textured lacustrine sediment or by glacial till. The Rauville soils have a surface layer of silt loam, and they lack a layer in which lime has accumulated. In many places all of these soils have a mat of partly decomposed organic matter on the surface.

All of these soils have moderately slow or slow permeability and high or very high available water capacity in the surface layer, in the subsoil, and in the layer where lime has accumulated. They have moderately slow or slow permeability and high available water capacity where the substratum is moderately fine textured or fine textured, and they have rapid permeability and very low available water capacity where the substratum is sand and gravel. Because these soils are in nearly level areas or in depressions, water ponds on their surface much of the time. A seasonal water table is at the surface or is within 5 feet of the surface during the wettest parts of the year.

The chief limitation to use of these soils for farming is wetness caused by the high water table and by ponding of water from runoff. In most places artificial drainage is impractical. The soils are used for growing hay, for pasture, or as wildlife habitat. They are more suitable for producing forage from native plants than any of the other soils in the county.

The dominant native vegetation where the pastures are in good condition consists of bulrush, rivergrass, sloughsedge, northern reedgrass, and Rydberg sunflower. Rivergrass and sloughsedge, which are dominant on the Parnell soil, are highly preferred forage for cattle. These soils provide good grazing for cattle, but sheep generally avoid these areas and overgraze adjacent sites. Overgrazing results in the loss of the more desirable plants, including Rydberg sunflower, rivergrass, and sloughsedge. It results in an increase in such less desirable plants as American sloughgrass, spike-sedge, Baltic rush, and foxtail barley. The loss of Rydberg sunflower is an early indication of overgrazing. Where all the native vegetation has been destroyed, desirable forage plants can be restored in the

stand by seeding reed canarygrass or Garrison creeping foxtail. When these soils are dry enough that the crop can be harvested at the proper time, they are excellent for growing hay.

CAPABILITY UNIT VIe-Sa

This capability unit consists only of the mapping unit Maddock-Hecla complex, severely eroded. The soils in this complex are nearly level to sloping, and they are well drained and moderately well drained. They have a surface layer of light sandy loam or loamy sand that is underlain by a substratum of medium sand. Severe erosion has removed all of the original surface layer in some areas. In other places the original surface layer has been buried. Shallow blowouts and low, stabilized dunes are common. Some areas contain deep blowouts and active sand dunes.

Permeability is moderately rapid, and the available water capacity is low. Runoff is slow. The water table is very deep.

Their low available water capacity and their very high susceptibility to soil blowing if they are cultivated make these soils suitable only for hay and pasture or for use as wildlife habitat. The dominant native vegetation when the pastures are in good condition is prairie sandreed and sand bluestem on the hummocks, and big bluestem in the swales. It is important that a good cover of plants be kept on the pastures at all times. If the pastures are overgrazed, the native plants are replaced by ones that are less desirable for grazing, for example, fringed sagewort, field sagewort, and Kentucky bluegrass. Kentucky bluegrass is well suited to grazing in spring. It is less suitable for grazing in summer than the native grasses when the pastures are in good condition.

CAPABILITY UNIT VIe-Si

This capability unit consists of moderately well drained Fairdale and LaPrairie soils on channeled bottom lands; of hilly and steep, excessively drained Buse soils; and of hilly and steep, well-drained Barnes and Zell soils and moderately well drained Gardena soils. All of these soils are deep. The Fairdale soils have a surface layer of silt loam that is underlain by a loamy substratum. The LaPrairie, Barnes, and Gardena soils have a surface layer of loam, silt loam, or silty clay loam, and a loamy subsoil and substratum. The Buse and Zell soils have a surface layer of loam or silt loam. They contain a layer of strongly calcareous, loamy material in which lime has accumulated, and they have a loamy substratum.

All of the soils, except the LaPrairie, have moderate permeability in the surface layer, and they have moderate to slow permeability below the surface layer. The LaPrairie soils are moderately permeable throughout. All of the soils have high or very high available water capacity. Runoff is rapid on all of the soils, except the Fairdale and LaPrairie, and it is slow on those soils. All of the soils, except the Fairdale and LaPrairie, have a very deep water table. The Fairdale and LaPrairie soils are flooded at times.

The chief limitations to use of these soils for crops are droughtiness and susceptibility of the steep areas to water erosion. In addition, the Fairdale and LaPrairie soils on channeled bottom lands are nearly inaccessible for farm machinery. Because of these limitations, the soils are used only for hay or pasture and as wildlife habitat. The dominant native vegetation where the pastures are in good condition is porcupinegrass, green needlegrass, and big bluestem. The cover of plants also includes a minor amount of other grasses, sedges, and forbs.

It is important that a good cover of plants be maintained on the pastures at all times. If the pastures are overgrazed, the more desirable grasses are replaced by less desirable plants. Needle-and-thread and western wheatgrass increase during the early stages of overgrazing. As overgrazing becomes more severe, Kentucky bluegrass, needleleaf sedge, curlycup gumweed, and fringed sagewort replace the taller grasses. Quackgrass, bromegrass, and Kentucky bluegrass have invaded areas where cultivation was attempted, or where the native grasses were buried by wind-deposited, silty material eroded from adjacent areas. They are suitable for grazing in spring, but they are less suitable for grazing in summer than are the native grasses when the pastures are in good condition.

CAPABILITY UNIT VIs-Cp

This capability unit consists of a complex of deep, nearly level, somewhat poorly drained Cavour soils. These soils have a surface layer of clay loam, a subsurface layer of loam, a dense claypan subsoil, and a substratum of loamy glacial till.

Permeability is moderately slow in the surface layer, the subsurface layer, and the substratum. It is slow in the claypan subsoil. The available water capacity is moderate. Runoff is slow, and a seasonal water table is within 3 to 5 feet of the surface during the wettest parts of the year.

The chief limitations to use of these soils for crops are droughtiness caused by the shallow root zone and the salinity of the substratum. Because of the dense claypan, only a few roots can penetrate the subsoil. As a result, these soils are used only for hay and pasture or as wildlife habitat. The native vegetation is mainly western wheatgrass, green needlegrass, porcupinegrass, silverleaf scurfpea, and needle-and-thread, but inland saltgrass, which is of limited value for hay and pasture, is dominant in many areas. It is important that a good cover of plants be maintained on the pastures at all times. If the pastures are overgrazed, the few palatable grasses are replaced by weeds and by inland saltgrass. If overgrazing is severe, all the vegetation is destroyed and the bare soils are then susceptible to soil blowing.

CAPABILITY UNIT VIs-Si

This capability unit consists of deep, nearly level, stony, somewhat poorly drained and poorly drained Antler and Gilby soils; of nearly level, stony, moderately well drained Svea soils; of nearly level to sloping, stony, well-drained Barnes soils; and of a steep, stony, excessively drained Buse soil. The Antler, Gilby, and Buse soils have a surface layer of stony loam or stony clay loam. They contain a layer of strongly calcareous loam or clay loam in which lime has accumulated, and they have a loamy substratum. The Barnes and Svea soils have a surface layer of stony loam, a subsoil of clay loam, and a loamy substratum.

These soils are moderately to slowly permeable and have high or very high available water capacity. Runoff ranges from slow to rapid, depending on the degree of slope. Except for the Antler and Gilby soils, which have a seasonal water table within 1 to 4 feet of the surface during wet periods, all of the soils have a very deep water table.

The many stones and boulders on the surface are the chief limitation to use of these soils for crops. Because of these stones and boulders, the soils are used only for pasture and as wildlife habitat. The dominant native vegetation is porcupinegrass, green needlegrass, and big bluestem. The cover of plants also includes minor amounts of other grasses, sedges, and forbs. It is important that a good cover of plants be maintained on the pastures at all times. If the pastures are overgrazed, the more desirable grasses are replaced by less desirable plants. Needle-and-thread and western wheatgrass increase during the early stages of overgrazing. As overgrazing becomes more severe, Kentucky bluegrass, needleleaf sedge, curlycup gumweed, and fringed sagewort replace the taller grasses. Quackgrass, bromegrass, and Kentucky bluegrass have invaded areas where cultivation has been attempted, or where the native grasses have been covered by wind-deposited, silty material blown from adjacent areas. They are suitable for grazing in spring, but they are not so well suited to grazing in summer as the native plants when the pastures are in good condition.

CAPABILITY UNIT VIs-SS

This capability unit consists of deep, strongly saline, poorly drained Hegne, Ludden, Ryan, and Ojata soils that are level or nearly level. These soils have a moderately fine textured or fine textured surface layer that is underlain by loamy or clayey lacustrine or alluvial sediment. Just below the surface layer, some of these soils have a layer of strongly calcareous material in which lime has accumulated. Others contain a buried surface layer.

These soils have moderate to slow permeability, depending on the texture of the various layers. All of them have high or very high available water capacity. A seasonal water table is at the surface or is within 5 feet of the surface during the wettest parts of the year. Runoff is very slow.

Because of their strong salinity and poor natural drainage, these soils are used for hay and pasture or as wildlife habitat. The cover of native plants when the pastures are in good condition varies greatly in composition, depending on the degree of salinity of the soils. The more important grasses in most areas, however, are western wheatgrass, alkali cordgrass, prairie cordgrass, slender wheatgrass, and Nuttall alkaligrass.

These soils provide better grazing for cattle than for sheep because cattle utilize the coarser grasses that sheep usually avoid. It is important that a good cover of plants be kept on the pastures at all times. If the pastures are overgrazed, the more desirable grasses are replaced by foxtail barley, inland saltgrass, alkali muhly, mat muhly, and other plants that have little value for grazing. Invasion by curlycup gumweed is an early indicator of overgrazing.

CAPABILITY UNIT VIs-Sw

This capability unit consists only of a complex of moderately steep and steep, shallow, well-drained Kloten soils. These soils have a loam surface layer. The surface layer is underlain by loamy glacial till that is 13 to 20 inches deep over shale bedrock.

These soils have moderate permeability in the surface layer, moderately slow permeability in the underlying glacial till, and slow permeability in the shale bedrock. They have high available water capacity above the shale bedrock, and low available water capacity in the bedrock. Runoff is rapid, and the water table is very deep.

The chief limitations to use of these soils for crops are droughtiness and susceptibility to water erosion. Droughtiness is caused by the shallow root zone and by the rapid runoff. Water erosion is the greatest hazard where the cover of plants has been removed. Because of these limitations, the soils are used only for hay and pasture or as wildlife habitat. The native vegetation is deciduous trees and shrubs and shade-tolerant grasses. Some areas of open grassland occur where the shale bedrock has limited the penetration of roots of some plants to the extent that the plants could not survive. Western wheatgrass and green needlegrass are the dominant grasses in these open areas.

It is important that a good cover of plants be maintained on the pastures at all times. If the pastures are overgrazed, the more desirable grasses are replaced by less desirable plants. If overgrazing is severe, all the cover of plants is removed and these soils are then highly susceptible to water erosion. In some areas where overgrazing has been severe, the soils are eroded down to the shale bedrock.

CAPABILITY UNIT VIs-SwG

This capability unit consists of deep, moderately steep, well-drained Barnes soils and of nearly level to steep, excessively drained Coe, Sioux, and Renshaw soils that are shallow over sand and gravel. The Barnes soils have a loam surface layer and a loamy subsoil and substratum. Most of the other soils have a loam or gravelly loam surface layer that is underlain by sand and gravel, but the Renshaw soils have a loamy subsoil.

The Barnes soils have moderate permeability in the solum, and moderately slow permeability in the substratum. They have high available water capacity, rapid surface runoff, and a very deep water table. The other soils have moderate permeability and moderate to high available water capacity in the layers above the sand and gravel, and rapid permeability and very low available water capacity in the sand and gravel. They have medium surface runoff and a very deep water table.

The chief limitations to use of these soils for crops are the steep slopes in many places and the droughtiness of all the soils, except the Barnes, caused by the shallow root zone and the low available water capacity of the sand and gravel substratum. Because of these limitations, these soils are used only for hay and pasture or as wildlife habitat. The dominant native vegetation when the pastures are in good condition is needle-and-thread, plains muhly, western wheatgrass, prairie sandreed, and silverleaf scurf-pea. It is important that a good cover of plants be maintained on the pastures at all times. If the pastures are overgrazed, the more desirable grasses are replaced by needleleaf sedge, fringed sagewort, blue gramagrass, and other undesirable plants.

CAPABILITY UNIT VIIe-1

The only mapping unit in this capability unit is Cashel soils, steep. These soils are on side slopes adjacent to the Red River. They are deep and are somewhat poorly drained. The surface layer of these soils is silty clay or clay. It is underlain by stratified flood plain deposits and by the surface layers of buried soils.

Permeability is moderately slow, and the available water capacity is high. Runoff is rapid. Except when these soils are flooded, the water table is very deep.

The steep slopes and susceptibility to streambank erosion are the main limitations to use of these soils for crops. The soils have only limited value for grazing, and they are used mainly as habitat for wildlife. The native vegetation is mostly deciduous trees and an understory of shrubs and shade-tolerant grasses. Maintaining the native vegetation in good condition is important, for severe streambank erosion results if the vegetation is removed.

Predicted yields

Predicted average acre yields of the principal crops grown in Walsh County under two levels of management are shown in table 2. These predictions are based on information obtained from farmers and other agricultural workers in the county. They are averages for a period long enough to include years of both favorable and unfavorable temperatures and moisture supply during the growing season. Many farmers obtain the yields shown in columns A, but a few get lower yields. Some farmers obtain the yields shown in columns B, and a few get even higher yields. Future yields are expected to increase on most of the soils as additional knowledge is gleaned from research and experience, as new management techniques are applied, and as better varieties of crops are developed.

Following are the practices used to obtain yields in columns A:

1. A general cropping system consists of small grains grown for 2 or 3 years, and summer fallow for 1 year. Wheat is planted on summer-fallowed land or on clean stubble if summer fallowing is not suitable for a particular soil. Wheat may be planted to follow potatoes or sugar beets, but yields are generally lower than where wheat is planted on soils that have been summer fallowed. Barley, flax, or potatoes follow wheat in the cropping system. Sugar beets are always planted on soils that have been summer fallowed.
2. Average or below optimum amounts of commercial fertilizer are applied.
3. Varieties of crops that have traditional acceptance in the area are planted, as opposed to newer varieties.
4. Herbicides are applied occasionally, but weeds are controlled mainly by tillage and by delaying seeding.
5. Tillage, planting, and harvesting are not always timely.
6. Erosion control practices are used to only a limited extent.

Following are the practices used to obtain yields in columns B:

1. A general cropping system consists of small grains grown for 2 or 3 years, and summer fallow for 1 year. Wheat is planted on soils that have been summer fallowed, or on clean stubble if summer fallow is not suitable for a particular soil. Wheat may also be planted to follow potatoes or sugar beets, but yields are generally less than where wheat is planted on soils that have been summer fallowed. Barley and flax follow wheat in the cropping system, which includes use of a green-manure crop if one is recommended for the soil.
2. Commercial fertilizer is applied according to the needs of crops included in the cropping system, and according to the needs indicated by the results of soil tests.
3. The newest adapted varieties of crops are planted, and seed that is clean and that has been treated for the prevention of disease is used for planting.
4. Insecticides, fungicides, and herbicides are applied where needed.
5. Tillage, planting, and harvesting are performed at the best times.
6. Soil erosion is controlled by applying the required conservation practices.

Use of Soils for Windbreaks [2]

Walsh County has a small acreage of native woodland, which is mainly along rivers and intermittent streams. From this wooded acreage, the early settlers obtained their fuel, fence posts, and poles. They also obtained logs that were sawed into rough lumber. The principal trees in the wooded areas today are American elm, boxelder, green ash, bur oak, basswood, and cottonwood. Chokecherry, plum, juneberry, and minor amounts of other shrubs grow in clumps along the fringes of wooded areas and in draws and coulees that lead to rivers and creeks. Areas now in native trees and brush are used to protect the watershed and as habitat for wildlife. Farmsteads located in wooded areas are protected from winds and storms by the native trees.

Trees and shrubs have been planted in Walsh County, mainly to provide windbreaks that can protect crops, livestock, wildlife, and farm buildings and that can conserve moisture and help to control soil blowing and the drifting of snow. Several types of windbreaks are generally planted. First are windbreaks containing one to three rows of trees and shrubs planted at intervals across cultivated fields to control soil blowing. Next are windbreaks containing five to 10 rows of trees and shrubs that are planted near the farmstead to protect buildings and livestock from wind and drifting snow, to provide shelter for wildlife, and to beautify the farmstead. The third type of windbreak contains 15 or more rows of trees and shrubs, and it is established near the farmstead or adjacent to a field to provide food and cover for wildlife. The fourth type is established as a screen to hide unsightly areas, to add color and contrast to open fields, and to beautify the landscape.

Since early days, most farmers in Walsh County have planted an effective windbreak around their buildings and feedlots. One of the first things an early settler did after he had selected a site for his farmstead was to plant trees on the north and west sides of the area where his house, barns, feedlots, and yard were to be located. Many of these original plantings still exist, and they still provide effective protection.

[2] By ELMER L. WORTHINGTON, woodland conservationist, Soil Conservation Service.

TABLE 2.—*Predicted average acre yields of principal crops*

[Yields in columns A can be expected under prevailing management; those in columns B can be expected under improved management. Dashes indicate that the soil is not suited or is not used extensively for the crop specified]

Soil	Wheat		Barley		Flax		Potatoes		Sugar beets		Alfalfa	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Antler stony clay loam	----	----	----	----	----	----	----	----	----	----	----	----
Antler clay loam	28	40	36	48	11	15	190	225	13	15	2.0	3.0
Arveson-Fossum fine sandy loams	20	25	25	30	8	10	----	----	----	----	1.5	2.5
Arveson-Fossum loams	20	30	25	35	8	12	----	----	----	----	1.5	2.5
Arvilla sandy loam, nearly level	13	17	16	20	6	8	----	----	----	----	.8	1.5
Arvilla sandy loam, gently sloping	12	16	15	19	5	7	----	----	----	----	.8	1.3
Barnes loam, rolling	22	32	28	36	8	12	----	----	----	----	1.0	1.5
Barnes loam, rolling, eroded	22	32	28	36	8	12	----	----	----	----	1.0	1.5
Barnes-Buse loams, hilly, eroded	16	22	18	26	6	9	----	----	----	----	1.0	1.5
Barnes-Buse stony loams	----	----	----	----	----	----	----	----	----	----	----	----
Barnes-Renshaw loams, rolling	16	22	18	24	6	9	----	----	----	----	1.0	1.5
Barnes-Sioux complex, hilly	----	----	----	----	----	----	----	----	----	----	----	----
Barnes-Svea loams, gently undulating	28	36	30	40	10	14	----	----	----	----	1.5	2.0
Barnes-Svea loams, gently undulating, eroded	28	36	30	40	10	14	----	----	----	----	1.5	2.0
Barnes-Svea stony loams, nearly level	----	----	----	----	----	----	----	----	----	----	----	----
Barnes-Svea stony loams, rolling	----	----	----	----	----	----	----	----	----	----	----	----
Bearden silt loam	34	44	40	55	14	17	200	275	14	17	2.0	3.0
Bearden silty clay loam, level	34	44	40	55	14	17	200	275	14	17	2.0	3.0
Bearden silty clay loam, sloping	24	30	26	36	10	14	----	----	----	----	1.5	2.5
Bearden silty clay loam, fans	34	44	40	60	14	17	225	300	14	17	2.0	3.0
Bearden silty clay loam, saline	15	20	20	30	6	8	----	----	10	12	1.0	2.0
Bearden silty clay loam, gravelly substratum	10	25	20	30	7	9	----	----	----	----	1.0	2.0
Bearden silty clay	34	44	40	55	14	17	200	250	14	17	2.0	3.0
Benoit loam	----	----	----	----	----	----	----	----	----	----	----	----
Borup silt loam [1]	20	30	30	40	6	12	150	210	12	14	1.5	2.5
Brantford-Vang loams, gently sloping	12	16	16	20	5	8	----	----	----	----	1.0	1.5
Brantford-Vang loams, sloping	10	14	14	17	4	6	----	----	----	----	1.0	1.3
Buse-Barnes loams, rolling	14	18	18	24	6	8	----	----	----	----	1.0	1.5
Buse-Barnes loams, hilly	----	----	----	----	----	----	----	----	----	----	----	----
Buse-Barnes loams, steep	----	----	----	----	----	----	----	----	----	----	----	----
Cashel silty clay, nearly level	25	40	35	45	13	16	----	----	13	15	2.0	3.0
Cashel silty clay, gently sloping	18	24	24	30	8	10	----	----	10	12	1.5	2.5
Cashel soils, steep	----	----	----	----	----	----	----	----	----	----	----	----
Cavour complex	----	----	----	----	----	----	----	----	----	----	----	----
Coe soils	----	----	----	----	----	----	----	----	----	----	----	----
Colvin silt loam	18	30	26	40	10	14	150	210	12	14	1.5	2.5
Colvin silty clay loam	18	30	26	40	10	14	150	210	12	14	1.5	2.5
Colvin silty clay loam, very wet	----	----	----	----	----	----	----	----	----	----	----	----
Divide loam, level	16	22	20	26	8	10	----	----	----	----	1.0	2.0
Edgeley loam, nearly level	28	36	32	40	10	14	160	200	----	----	1.4	2.0
Edgeley loam, gently undulating	22	28	26	32	8	10	----	----	----	----	1.3	1.8
Edgeley loam, undulating	16	24	20	26	6	8	----	----	----	----	1.0	1.5
Embden sandy loam, level	20	28	24	30	8	10	150	190	----	----	1.5	2.5
Embden sandy loam, gently undulating	16	24	20	26	7	9	----	----	----	----	1.3	2.5
Embden sandy loam, sloping	14	18	16	20	5	7	----	----	----	----	1.2	2.0
Embden loam, level	28	38	35	45	11	15	200	250	----	----	2.0	3.0
Fairdale silt loam	28	38	38	48	12	15	225	275	12	14	2.0	3.0
Fairdale silt loam, gently sloping	26	32	34	38	10	14	175	225	10	12	2.0	2.5
Fairdale silt loam, occasionally flooded	28	38	38	48	12	15	225	275	12	14	2.0	3.0
Fairdale and LaPrairie soils, channeled	----	----	----	----	----	----	----	----	----	----	----	----
Fargo silty clay, nearly level	30	38	35	45	12	16	150	225	12	15	2.0	3.0
Fargo silty clay, depressional [1]	20	35	25	40	8	14	----	----	8	14	1.0	3.0
Fargo-Hegne silty clays, level	30	38	35	50	12	16	150	225	13	15	2.0	3.0
Fargo-Hegne silty clays, gently sloping	18	28	26	36	9	12	150	200	10	12	1.5	2.5
Gardena silt loam, nearly level	35	45	40	60	14	17	225	300	13	16	2.0	3.0
Gardena silt loam, gently sloping	28	36	30	45	10	14	175	225	----	----	2.0	3.0
Gilby loam	30	40	38	48	12	15	200	250	13	15	2.0	3.0
Gilby loam, wet [1]	18	25	24	34	8	10	----	----	----	----	1.5	2.5
Gilby stony loam	----	----	----	----	----	----	----	----	----	----	----	----
Glyndon silt loam, level	35	45	40	60	14	17	225	300	14	17	2.0	3.0
Glyndon silt loam, gently sloping	25	35	30	45	10	14	175	225	12	15	2.0	3.0

See footnote at end of table.

TABLE 2.—*Predicted average acre yields of principal crops*—Continued

Soil	Wheat		Barley		Flax		Potatoes		Sugar beets		Alfalfa	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*
Glyndon silt loam, moderately saline	15	20	20	30	6	8	------	------	10	12	1.0	2.0
Grano silty clay, very wet	------	------	------	------	------	------	------	------	------	------	------	------
Grano-Hegne silty clays	15	28	20	35	10	12	------	------	9	14	1.5	2.0
Hamar and Ulen loamy sands	14	18	16	22	6	8	------	------	------	------	2.0	2.5
Hamar and Ulen sandy loams	15	20	22	30	8	10	------	------	------	------	2.0	2.5
Hamerly-Cresbard loams	16	24	22	28	6	8	------	------	------	------	1.0	1.5
Hamerly-Svea loams, nearly level	28	36	30	40	10	14	------	------	------	------	1.0	1.6
Hamerly-Svea loams, gently undulating	26	34	28	38	9	13	------	------	------	------	1.0	1.6
Hattie silty clay, lacustrine	14	20	20	26	6	8	150	200	8	10	1.5	2.5
Hecla loamy sand, nearly level	14	18	16	20	6	8	------	------	------	------	1.0	2.0
Hecla loamy sand, gently undulating	12	16	12	16	5	7	------	------	------	------	1.0	3.0
Hegne-Fargo silty clays, nearly level	30	38	35	45	12	16	175	225	12	15	2.0	2.0
Hegne-Fargo silty clays, gently sloping	18	28	26	36	9	12	150	200	10	12	1.5	2.5
Hegne silty clay, saline	15	20	20	30	5	8	------	------	10	12	1.0	2.0
Hegne silty clay, strongly saline-alkali	------	------	------	------	------	------	------	------	------	------	------	------
Kloten complex	------	------	------	------	------	------	------	------	------	------	------	------
Lamoure soils, moderately saline	12	18	18	26	5	8	------	------	10	12	1.0	2.0
Lankin loam, level	30	42	40	50	13	16	225	250	13	15	2.0	3.0
Lankin clay loam	30	42	40	50	13	16	225	250	13	15	2.0	3.0
Lankin and Svea loams, nearly level	28	36	32	42	10	14	160	200	------	------	1.4	2.0
Lankin and Svea loams, gently sloping	24	28	26	34	8	10	------	------	------	------	1.0	2.0
LaPrairie silt loam	30	40	40	50	13	16	225	300	13	15	2.0	3.0
LaPrairie silty clay loam	30	40	40	50	13	16	225	300	13	15	2.0	3.0
Ludden silty clay [1]	15	25	25	36	6	12	------	------	7	12	1.5	2.5
Ludden and Ryan soils	------	------	------	------	------	------	------	------	------	------	------	------
Maddock-Hecla complex, severely eroded	------	------	------	------	------	------	------	------	------	------	------	------
Manfred soils	------	------	------	------	------	------	------	------	------	------	------	------
Ojata soils	------	------	------	------	------	------	------	------	------	------	------	------
Overly silt loam, level	35	45	40	60	14	17	225	300	14	17	2.0	3.0
Overly silty clay loam, level	35	45	40	60	14	17	225	300	14	17	2.0	3.0
Overly silty clay loam, gently sloping	28	36	30	45	11	14	175	225	10	12	2.0	3.0
Overly silty clay loam, sloping	22	28	24	38	8	12	------	------	------	------	1.5	2.5
Overly silty clay loam, fans	35	45	40	60	14	17	225	300	14	17	2.0	3.0
Overly silty clay, level	35	45	40	60	14	17	225	275	14	17	2.0	3.0
Overly silty clay, fans	35	45	40	60	14	17	225	275	14	17	2.0	3.0
Parnell silty clay loam	------	------	------	------	------	------	------	------	------	------	------	------
Parnell and Tonka soils [1]	25	40	30	45	10	14	------	------	------	------	1.0	3.0
Perella silty clay loam [1]	25	40	30	45	10	14	150	250	9	15	1.0	3.0
Rauville soils	------	------	------	------	------	------	------	------	------	------	------	------
Renshaw loam, nearly level	14	20	18	24	7	9	------	------	------	------	1.0	1.5
Renshaw loam, gently sloping	12	16	16	20	5	8	------	------	------	------	1.0	1.3
Rockwell fine sandy loam	22	30	28	38	10	12	180	225	------	------	1.5	2.5
Sioux-Renshaw complex	------	------	------	------	------	------	------	------	------	------	------	------
Sioux and Renshaw soils, steep	------	------	------	------	------	------	------	------	------	------	------	------
Svea-Barnes loams, nearly level	30	38	32	42	10	14	175	200	------	------	1.5	2.2
Svea-Cresbard loams, nearly level	24	30	26	36	8	12	------	------	------	------	1.0	1.8
Towner sandy loam, level	22	30	28	38	10	12	180	225	------	------	1.5	2.5
Ulen sandy loam	20	30	28	38	10	12	180	225	------	------	1.5	2.5
Vallers loam, saline	10	16	16	22	5	8	------	------	------	------	1.0	1.5
Vallers-Hamerly loams	15	20	20	25	7	9	------	------	------	------	1.0	2.0
Vallers-Hamerly stony loams	------	------	------	------	------	------	------	------	------	------	------	------
Vang-Brantford loams, nearly level	16	20	18	26	7	9	------	------	------	------	1.0	1.5
Wahpeton silty clay	30	40	40	50	13	16	190	225	13	15	2.0	3.0
Walsh loam, sloping	20	28	20	28	8	10	------	------	------	------	1.0	1.5
Walsh loam, sand substratum, nearly level	24	30	26	36	10	12	160	200	------	------	1.5	2.0
Walsh loam, sand substratum, gently sloping	18	24	24	30	8	10	------	------	------	------	1.2	1.8
Walsh silt loam	28	40	30	42	12	16	210	260	------	------	1.5	2.0
Walsh clay loam, level	30	40	32	42	12	16	210	260	------	------	1.5	2.0
Waukon loam, gently undulating	28	36	30	40	10	14	------	------	------	------	1.5	2.0
Waukon loam, strongly rolling	16	22	18	26	6	9	------	------	------	------	1.0	1.5
Zell-Gardena silt loams, sloping	16	24	20	28	8	10	------	------	------	------	1.0	2.0
Zell-Gardena silt loams, steep	------	------	------	------	------	------	------	------	------	------	------	------

[1] Yields apply to areas where surface drainage is adequate.

Most of the original windbreaks consisted entirely of trees. Since the windbreak contained no shrubs, snow blew through it and drifted onto yards and feedlots. Most windbreaks of this type have been improved by planting rows of shrubs along the windward side of the trees. Where landowners have had enough space, many of them have planted completely new windbreaks to provide better protection for their farmstead.

In winter a good windbreak can reduce the cost of heating the home, as well as keeping the yard and feedlots free of drifting snow. In summer it protects the home, barns, feedlots, gardens, and orchards from hot winds. Most windbreaks are planted along the north and west sides of the farmstead. Therefore, the trees do not block circulation of air in summer. In recent years, however, some landowners have planted single or double rows of shrubs along the south and east sides of their farmsteads. Such plantings are beneficial because they effectively trap snow in winter. Yet, they allow natural circulation of air around the farm buildings, feedlots, and yards. Tall trees surrounding a farmstead cut off the flow of air and can make a farmstead stifling hot in summer.

Windbreaks used to protect farmsteads in this county are generally about 2 acres in size. The quality of these windbreaks compares favorably with the quality of windbreaks in other parts of North Dakota.

Table 3 describes the soils of 10 windbreak sites in Walsh County, provides soil suitability ratings for specified trees and shrubs suitable for use in windbreaks, and gives estimates of the heights of these trees or shrubs

TABLE 3.—*Soils and their suitability for adapted*

Soils in windbreak sites		Description of soils
Windbreak site 1: Antler: Ao. Bearden: Bm, BnA, BnC, Bo, Bs, Bt. Cashel: CaA, CaB. Embden: EmA, EmB, EmC, EnA. Fairdale: Fa, FaB, Fd. Fargo: FfA. Fargo-Hegne: FhA, FhB. Gardena: GaA, GaB. Gilby: Gb. Glyndon: GlA, GlB. Hamerly-Cresbard: He. (For Cresbard part of He, see windbreak site 4.) Hamerly-Svea: HgA, HgB. Hecla: HlA, HlB.	Hegne-Fargo: HmA, HmB. Lankin: LeA, Lk. Lankin-Svea: LnA, LnB. LaPrairie: Lp, Lr. Overly: OeA, OlA, OlB, OlC, Om, OvA, Ow. Svea-Barnes: SuA. Svea-Cresbard: SvA. (For Cresbard part of SvA, see windbreak site 4.) Towner: ToA. Ulen: Un. Wahpeton: Wa. Walsh: WhC, WlA, WlB, Wm, WnA. Waukon: WoB.	Deep, nearly level to sloping loamy sands to silty clays. These soils have favorable water-supplying capacity. Little water runs off, and the water table is within reach of tree roots most of the time. Some soils are strongly sloping and have formed under a mixed cover of grass and trees. Others are nearly level and are flooded for short periods in spring. In some places the surface layer is noncalcareous and is neutral in reaction; in others it is calcareous. These soils are well suited to all types of windbreaks. The Walsh soils are especially well suited to evergreen trees.
Windbreak site 2: Arveson-Fossum: As, At. Borup: Bv. Colvin: Cf, Ch, Co.[1] Divide: DdA. Fargo: Fg. Gilby: Ge. Grano: Gr.[1] Grano-Hegne: Gs. (For Hegne part of Gs, see windbreak site 1.)	Hamar and Ulen: Ha, Hd. (For Ulen part of Ha, Hd, see windbreak site 1.) Manfred: Mn.[1] Parnell: Pa.[1] Parnell and Tonka: Pt. Perella: Pu. Rockwell: Ro.	Poorly drained loamy sands to silty clays that are neutral in reaction or are calcareous throughout. In places the substratum is nonsaline; in others it is slightly saline. Water stands on these soils part of the time. Suitability ratings for trees and shrubs assume that drainage is provided.
Windbreak site 3: Barnes: BaC, BaC2. Barnes-Buse: BbD2. Barnes-Renshaw: BgC. (For Renshaw part of BgC, see windbreak site 6.) Barnes-Sioux: BhD. (For Sioux part of BhD, see windbreak site 10.)	Barnes-Svea: BkB, BkB2. (For Svea part of BkB and BkB2, see windbreak site 1.) Edgeley: EbA, EbB, EbC. Vang-Brantford: VnA. (For Brantford part of VnA, see windbreak site 6.) Waukon: WoD.	Deep, well-drained loams are in this windbreak group. Most of these soils have a substratum of medium-textured glacial till, but the substratum is gravelly and is at a depth of 20 to 40 inches in a small acreage. Some water runs off, and the water table is beyond the reach of tree roots. Practices that conserve moisture are needed where slopes are stronger than 6 percent if satisfactory growth of trees is to be obtained.

See footnotes at end of table.

at their maturity. Soil suitability ratings given in table 3 are based on the estimated vigor and growth of the trees and shrubs. Vigor and growth can be estimated where one or more of the following conditions are present.

The rating is *good* where—

Leaves or needles are normal in color and growth.
The crowns contain only a small amount of dead twigs and branches.
Damage from insects and diseases and from the effects of climate is obvious.
Evidence of suppression is slight.

The rating is *fair* where—

Leaves or needles are abnormal in color and growth.
The crowns contain a substantial amount of dead twigs and branches.
Damage from insects and diseases and from the effects of climate is obvious.
Evidence of suppression is obvious, and the current year's growth is less than normal.

The rating is *poor* where—

Leaves or needles are very abnormal in color and growth.
The crowns contain a very large amount of dead twigs and branches.
Damage from insects and diseases and from the effects of climate is extensive.
Evidence of suppression is severe, and the current year's growth is negligible.

trees by windbreak sites, and estimated heights of trees

Suitability ratings of soils for adapted trees, and estimated heights of trees in feet at maturity											
Ash	American elm	Siberian elm	Cottonwood	Cedar	Pine	Spruce	Russian-olive	Honeysuckle	Caragana	Chokecherry	Plum
Good; 24 to 28.	Good; 24 to 28.	Good; 30 to 34.	Good; 50 to 55.	Good; 11 to 13.	Good; 20 to 24.	Good; 16 to 20.	Good; 20 to 22.	Good; 9 to 10.	Good; 10 to 11.	Good; 14 to 16.	Good; 8 to 10.
Good; 22 to 24.	Good; 22 to 24.	Good; 26 to 30.	Fair to good; 36 to 40.	Good; 13 to 15.	Good; 20 to 24.	Good; 18 to 20.	Good; 18 to 20.	Good; 8 to 9.	Good; 8 to 9.	Good; 10 to 12.	Good; 7 to 8.
Good; 20 to 22.	Good; 20 to 22.	Good; 22 to 26.	Fair to good; 34 to 38.	Good; 12 to 14.	Good; 20 to 22.	Good; 17 to 19.	Good; 16 to 18.	Good; 7 to 8.	Good; 10 to 11.	Good; 8 to 9.	Good; 9 to 10.

TABLE 3.—*Soils and their suitability for adapted trees*

Soils in windbreak sites		Description of soils
Windbreak site 4: Cresbard loams. (Mapped only in complexes with Hamerly and Svea soils.)		Deep, moderately well drained claypan soils of the Cresbard series make up this site. The surface layer is loam that is neutral in reaction and is about 7 inches thick, and the subsoil is slightly alkaline, dense clay about 9 inches thick. The substratum is strongly alkaline at a depth of about 30 inches. Part of the moisture from precipitation is lost because of the slow permeability of the substratum.
Windbreak site 5: Maddock-Hecla: Mk3. (For Hecla part of Mk3, see windbreak site 1.)		Deep, well drained and moderately well drained, sandy soils that are severely eroded make up this site. The surface layer is sandy loam or loamy sand that is neutral in reaction. The available water capacity is moderately low, but the surface layer absorbs water rapidly. The water table is beyond the reach of tree roots.
Windbreak site 6: Arvilla: AuA, AuB. Brantford-Vang: BwB, BwC. (For Vang part of BwB and BwC, see windbreak site 3.)	Renshaw: ReA, ReB.	Medium-textured and moderately coarse textured, shallow soils over coarse sand and gravel comprise this site. Gravel is at a depth of 15 to 25 inches. The surface layer is neutral in reaction, and the water table is beyond reach of tree roots. Although these soils are droughty, they are suitable for windbreaks.
Windbreak site 7: Soils of this site were not mapped in Walsh County.		Loamy sands and sands underlain by a sandy subsoil and substratum. These soils absorb water rapidly, but they have a low available water capacity. They are not suitable for windbreaks and therefore are not rated.
Windbreak site 8: Buse-Barnes: ByC, ByD. (For Barnes part of ByC, see windbreak site 3.) Hattie: Hh.	Zell-Gardena: ZgC, ZgE. (For Gardena part of ZgC and ZgE, see windbreak site 1.)	Deep, calcareous soils that occupy convex slopes of 6 to 15 percent. Rapid runoff requires the use of practices that conserve water for the growth of trees.
Windbreak site 9: Bearden: Br. Cavour: Cd. Glyndon: Gm. Hegne: Hn. Lamoure: La.	Vallers: Va. Vallers-Hamerly: Vh. (For Hamerly part of Vh, see windbreak site 1.)	Sodic and saline soils with claypan subsoil. These soils are not suitable for trees and shrubs. In moderately saline soils, the root zone is less than 20 inches deep. Salinity and alkalinity make the soils of this site droughty.
Windbreak site 10: Antler: An. Barnes-Buse: Be. Barnes-Svea: BlA, BlC. Benoit: Bu. Buse-Barnes: ByE. Cashel: CcE.[3] Coe: Ce. Fairdale and LaPrairie: Fe.[3] Gilby: Gh. Hegne: Hs. Kloten: Kn.[3]	Ludden: Lu, Ly. Ojata: Oa. Rauville: Ra. Sioux-Renshaw: Sr. (For Renshaw part of Sr, see windbreak site 6.) Sioux and Renshaw: SsE. (For Renshaw part of SsE, see windbreak site 6.) Vallers-Hamerly: Vm.	Soils in this site are shallow over gravel, strongly saline, wet from seepage, ponded, too low for drainage, and too stony or too steep for cultivation. They are unsuitable for windbreaks that require cultivation. Some of these soils have a natural growth of trees and shrubs, but the soils are too erodible and droughty for the growing of plants that require cultivation. Soils of this site are not rated for suitability.

[1] For undrained areas of Co (Colvin), Gr (Grano), Mn (Manfred), and Pa (Parnell), see windbreak site 10.
[2] Suitability is poor; height at maturity, variable.

by windbreak sites, and estimated heights of trees—Continued

Suitability ratings of soils for adapted trees, and estimated heights of trees in feet at maturity											
Ash	American elm	Siberian elm	Cotton-wood	Cedar	Pine	Spruce	Russian-olive	Honey-suckle	Cara-gana	Choke-cherry	Plum
Fair; 18 to 20.	Fair; 17 to 19.	Good; 20 to 24.	(2)	Good; 11 to 13.	Good; 18 to 20.	(2)	Fair; 14 to 16.	Good; 8 to 9.	Fair; 6 to 7.	Fair; 7 to 8.	Fair; 6 to 7.
Good; 18 to 20.	Fair; 18 to 20.	Good; 20 to 24.	(2)	Good; 10 to 12.	Good; 14 to 16.	(2)	Fair; 13 to 15.	Good; 7 to 8.	Fair; 6 to 7.	Good; 11 to 13.	Fair; 6 to 7.
Fair; 14 to 16.	Fair; 14 to 16.	Good; 20 to 22.	(2)	Fair; 8 to 10.	Fair; 15 to 17.	(2)	Good; 15 to 17.	Fair; 6 to 7.	Good; 7 to 8.	Fair; 8 to 9.	Fair; 6 to 7.
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Fair; 12 to 14.	Fair; 12 to 14.	Fair; 16 to 18.	(2)	Fair; 9 to 10.	Fair; 14 to 16.	(2)	Fair; 13 to 15.	Fair; 6 to 7.	Fair; 6 to 7.	(2)	Fair; 4 to 5.
Fair; 11 to 13.	Fair; 11 to 13.	Fair; 16 to 18.	(2)	Fair; 7 to 9.	Fair; 13 to 15.	(2)	Fair; 12 to 14.	Fair; 6 to 7.	Fair; 6 to 7.	(2)	Fair; 4 to 5.
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[3] These are nonarable soils, but they have trees growing naturally on part or most of their areas.

Use of Soils for Wildlife [8]

Wildlife provides a limited source of outdoor recreation for people in this area. Some recreational features attributable to wildlife have been lost through neglect, but it is likely that some of these features can be restored. This section gives facts about the main species of wildlife in Walsh County, and it lists names of soil associations that are best suited to each species of wildlife.

The most important species of wildlife in the county are gray partridge, mink, duck, muskrat, and white-tailed deer. In addition, the population of geese and the number of places where they can be hunted have increased as a result of development of the areas around Ardoch and Salt Lakes and through watershed developments in the central part of the county.

Public fishing in this county is restricted mainly to the Red River and to the Homme Reservoir. Some of the reservoirs created by dams being built under Public Law 566 are planned as combined fishery and flood control projects. Sites for fish dams are limited. The best potential for these is in soil association 6.

Of all the game birds in the county, the mourning dove has the highest potential as a source of recreation, but the potential is not being realized. Pheasant, sharp-tailed grouse, ruffed grouse, and prairie chicken are not plentiful in this county. In general, the severity of the climate in winter precludes establishing quality cover for pheasant, and the grouse and prairie chicken have such a restricted habitat that it is impractical to manage for them. Hawks, owls, insectiverous birds, song birds, and shore birds also inhabit this county. The hawks, owls, and insectiverous birds probably are of greater economic value than the others because they provide a control on small rodents and insects.

The kind of habitat determines the species of wildlife and their population in a given area, and land use and management of the soils, in turn, determine the kind, amount, and distribution of the habitat. Almost all species of wildlife in the county mainly inhabit areas along rivers, creeks, and coulees, and other places that are in permanent vegetation. Such areas not only have unlimited value for wildlife, but they are also important for their esthetic value. Because the distribution of wildlife is so closely related to the use and management of the soils, it is discussed in relationship to soil associations, which are described in detail in the section "General Soil Map."

Table 4 indicates the suitability of the soil associations for selected kinds of wildlife. It is also a guide to the results that can be expected where soils are managed for gray partridge, mink, muskrat, duck, or white-tailed deer. A rating of *good* means that the soil can be easily managed to provide suitable habitat for the stated species of wildlife. A rating of *fair* or *poor* means that the soil is less easily managed for providing suitable habitat for wildlife. The suitability of the soil associations for the five species of wildlife indicated in table 4 is based on present land use and on the case of establishing and maintaining suitable habitat.

Landowners who wish to improve the habitat for wildlife should first evaluate the present habitat to make certain that the improvements they plan are actually needed. After the need has been determined, the most suitable kinds of vegetation and the best practices can be chosen that are

[8] By Erling B. Podoll, biologist, Soil Conservation Service.

TABLE 4.—*Suitability of soil associations for selected kinds of wildlife and potential breeding population per square mile*

Soil association	Partridge		Ducks		Mink		Deer		Muskrat[1]
	Rating	Number	Rating	Number	Rating	Number	Rating	Number	
1. Cresbard-Hamerly-Svea	Good	6–15	Good	51–250	Fair	2–4	Fair	2–4	Good.
2. Hamerly-Svea-Barnes	Good	6–15	Good	51–250	Fair	2–4	Fair	2–4	Good.
3. Barnes-Svea-Parnell	Good	6–15	Good	51–250	Fair	2–4	Fair	2–4	Good.
4. Svea-Barnes	Fair	2–5	Poor	0–15	Poor	0–1	Fair	2–4	Poor.
5. Barnes-Buse	Fair	2–5	Fair	16–50	Fair	2–4	Good	5–30	Fair.
6. Kloten-Edgeley	Fair	2–5	Fair	16–50	Fair	2–4	Good	5–30	Poor.
7. Buse-Fairdale	Poor	0–1	Fair	16–50	Good	5–10	Good	5–30	Fair.
8. Renshaw-Brantford-Sioux	Fair	2–5	Poor	0–15	Poor	0–1	Fair	2·4	Poor.
9. Embden-Hecla-Ulen	Fair	2–5	Poor	0–15	Poor	0–1	Fair	2–4	Poor.
10. Lankin-Gilby	Fair	2–5	Fair	16–50	Fair	2–4	Fair	2–4	Fair.
11. Walsh	Fair	2–5	Poor	0–15	Poor	0–1	Fair	2–4	Poor.
12. Glyndon-Gardena	Fair	2–5	Poor	0–15	Poor	0–1	Poor	0–1	Poor.
13. Bearden-Overly	Fair	2–5	Poor	0–15	Poor	0–1	Poor	0–1	Poor.
14. Bearden-Glyndon	Fair	2–5	Poor	0–15	Poor	0–1	Poor	0–1	Poor.
15. Overly-Bearden fans	Fair	2–5	Fair	16–50	Fair	2–4	Good	5–30	Poor.
16. Bearden-Glyndon moderately saline	Poor	0–1	Fair	16–50	Fair	2–4	Poor	0–1	Poor.
17. Hegne-Fargo	Fair	2–5	Poor	0–15	Poor	0–1	Poor	0–1	Poor.
18. Ojata-Hegne saline	Fair	2–5	Fair	16–50	Fair	2–4	Poor	0–1	Poor.
19. Fairdale-LaPrairie	Poor	0–1	Fair	16–50	Good	5–10	Good	5–30	Fair.
20. Wahpeton-Cashel-Fargo	Poor	0–1	Fair	16–50	Good	5–10	Good	5–30	Fair.

[1] Population related to permanency and acreage of wetlands.

properly suited to the soils. As a rule, cropland, woodland, and pasture are expected to produce desirable habitat and populations of wildlife if they are properly managed. If they do not produce the desired populations of wildlife, changing the land use may be necessary, or applying special practices that benefit wildlife may be desirable. Assistance in improving the habitat for wildlife can be obtained through representatives of the Soil Conservation Service or through State organizations that manage fish and game. In this survey the sections "Use of Soils for Windbreaks" and "Use of Soils for Engineering" provide information about the suitability of the soils for trees and shrubs and for some kinds of engineering practices.

Areas that have the highest potential as habitat for gray partridge, ducks, white-tailed deer, mink, muskrat, and fish are described in the paragraphs that follow.

Gray partridge.—This small game bird was introduced from Europe. For cover, it depends on the herbaceous vegetation in fence rows, in thickets, and on wetland. Soil associations 1, 2, and 3 have the highest potential for gray partridge.

Ducks.—The ducks produced and harvested in this county are mainly pintail, mallard, and blue-winged teal. Soil associations 1, 2, and 3 have the highest potential for production of ducks, but the Manfred, Tonka, and Arveson soils are also well suited. Opportunities for hunting ducks are good in soil association 18 and on the lakes, pond, and reservoirs throughout the county.

White-tailed deer.—In summer, deer are fairly well distributed throughout the county. In winter, they are restricted to wooded areas. Soil associations 5, 6, 7, 18, 19, and 20 have the highest potential for deer.

Mink.—Mink find excellent habitat along streams where there is a combination of springs, running water, and shrubs. Soil associations 7, 19, and 20 have the highest potential for production of mink.

Muskrat.—These animals require marshes of high quality. Their abundance depends on the permanence and acreage of areas of wetland. The kind of habitat in which muskrats thrive also produces waterfowl and good hunting at the same time. Soil associations 1, 2, and 3 have the highest potential for producing muskrats. Various streams in these associations support fair populations of muskrat.

Fish.—Public fishing in the county has been largely restricted to the Red River and the Homme Reservoir near Park River. Additional facilities for fishing are being provided by constructing multipurpose fisheries-flood control dams under the Public Law 566 Watershed Program. Sites for dams are somewhat limited, but soil association 6 has the best potential.

Use of Soils for Engineering [4]

Some soil properties are of interest to engineers because they affect construction and maintenance of engineering projects. Among the soil properties most important to engineers are permeability to water, shear strength, dispersion, compaction characteristics, drainage, shrink-swell properties, grain size, plasticity, and reaction. Other important properties are depth to water table, depth to bedrock, available water capacity, and relief. Such information is made available in this section. Engineers can use this information to—

1. Make studies that will aid in selecting and developing sites for industries, businesses, residences, and recreation areas.
2. Make preliminary estimates of soil properties that are significant in the planning of agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables, and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel, sand, and other construction material.
5. Correlate performance of engineering structures with soil mapping units to develop information for overall planning useful in designing and maintaining engineering structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps and reports and aerial photographs for the purpose of making soil maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

It should be emphasized that the interpretations made in this soil survey are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads or at a site where excavations are to be deeper than the depths of the layers here reported. Also, engineers should not apply specific values to the estimates for bearing capacity given in this survey. Nevertheless, by using this survey, an engineer can select and concentrate on those soil units that are most important for his proposed kind of construction, and in this manner reduce the number of soil samples required for laboratory testing and complete an adequate soil investigation at minimum cost.

Information of value in planning engineering work is given throughout the text, particularly in the sections "Descriptions of the Soils" and "Formation and Classification of Soils." Some terms used by soil scientists may be unfamiliar to engineers, and some words have different meanings in soil science than they have in engineering. Among the terms that have special meaning in soil science are gravel, sand, silt, clay, loam, surface soil, subsoil, and horizon. These and other terms are defined in the Glossary at the back of this survey. Most of the information about engineering is given in tables 5, 6, and 7. Information about sand and gravel resources in Walsh County is given in table 8.

[4] By WILTON M. GRADY, area engineer, Soil Conservation Service.

TABLE 5.—*Engi*

[Tests performed by North Dakota State University in cooperation with North Dakota State Highway Department and the Association of State Highway

Soil name and location	Parent material	North Dakota State University report No.	Depth from surface	Moisture density [1]	
				Maximum dry density	Optimum moisture
Brantford loam:		*NDH-*	*In.*	*Lb./cu. ft.*	*Pct.*
240 ft. W. and 0.2 mile S. of NE. corner of sec. 23, T. 155 N., R. 57 W. (Modal)	Sandy and gravelly glacial outwash.	95	0–4	95	24
		96	4–13	87	28
		97	29–60	103	19
0.13 mile N. of SE. corner of sec. 23, T. 155 N., R. 57 W. (From gravel pit)	Sandy and gravelly outwash.	98	0–8	83	30
		99	8–17	86	24
		100	25–46	115	15
Cresbard loam:					
120 ft. E. and 0.64 mile N. of SW. corner of sec. 35, T. 157 N., R. 57 W. (Shale substratum)	Glacial till.	104	7–14	92	25
		105	18–36	103	18
		106	36–58	115	13
0.25 mile N. of 60 ft. W. of SE. corner of sec. 9, T. 156 N., R. 57 W. (Modal)	Glacial till.	107	0–7	101	18
		108	9–16	105	18
		109	16–23	104	20
		110	40–58	103	19
0.2 mile E. and 1,180 ft. S. of W¼ corner of sec. 10, T. 156 N., R. 57 W. (Sand substratum)	Glacial till.	111	8–13	102	18
		112	13–18	96	21
		113	48–60	100	20
Embden sandy loam:					
0.16 mile E. and 0.3 mile N. of S¼ corner of sec. 24, T. 157 N., R. 56 W. (Modal)	Lacustrine beach sand.	117	0–6	102	19
		118	6–16	107	16
		119	25–36	101	20
100 ft. W. and 900 ft. N. of SE. corner of sec. 36, T. 157 N., R. 56 W. (Fine sand substratum)	Water-deposited sand over glacial till.	114	0–8	108	16
		115	8–20	112	14
		116	24–40	104	18
0.4 mile W. of NE. corner of sec. 8, T. 156 N., R. 55 W. (Gravel substratum)	Water-deposited sand.	120	0–10	110	15
		121	10–20	117	13
		122	34–44	112	11
		123	44–62	131	9
Glyndon silt loam:					
180 ft. E. and 1,300 ft. S. of NW. corner of sec. 9, T. 158 N., R. 52 W. (Modal)	Lacustrine silt and fine sand.	84	0–8	94	24
		85	8–14	101	21
		86	14–28	109	17
		87	28–38	103	17
		88	38–55	104	18
		89	55–72	100	22
820 ft. S. and 430 ft. W. of NE. corner of sec. 21, T. 158 N., R. 52 W. (Silty clay substratum)	Lacustrine silt and fine sand.	80	0–9	96	22
		81	27–35	108	16
		82	35–43	104	21
		83	45–60	100	17
240 ft. S. and 150 ft. W. of NE. corner of sec. 1, T. 158 N., R. 54 W. (Very fine sand substratum)	Lacustrine silt and fine sand.	69	0–9	100	20
		70	9–16	104	18
		71	16–25	108	16
		72	25–60	104	18

See footnotes at end of table.

neering test data

U.S. Department of Commerce, Bureau of Public Roads (BPR), in accordance with standard procedures of the American Officials (AASHO)(*1*)]

Mechanical analysis [2]										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—						Percentage smaller than—						AASHO	Unified
¾ in.	⅜ in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
100	97	95	87	65	41	30	14	5	2	47	17	A-7-5(3)	SM
100	98	92	78	58	34	25	14	8	4	36	13	A-2-6(1)	SM-SC
[4] 97	88	62	41	18	12	8	4	2	0	[5] NP	[5] NP	A-1-a(0)	SW-SM
100	96	94	87	63	47	36	17	4	2	64	22	A-7-5(7)	SM
[4] 99	94	70	46	31	24	16	7	3	2	54	20	A-2-7(2)	SM
[4] 86	68	50	30	11	8	7	5	2	1	NP	NP	A-1-a(0)	GW-GM
-------	-------	100	98	87	73	66	51	34	28	64	43	A-7-6(19)	CH
100	99	97	92	81	63	56	43	30	24	41	23	A-7-6(11)	CL
100	99	99	94	49	23	21	16	12	9	NP	NP	A-1-b(0)	SM
-------	100	99	98	86	60	49	28	12	7	35	11	A-6(5)	ML-CL
100	99	96	91	80	58	51	35	24	18	39	22	A-6(9)	CL
100	96	93	88	76	57	50	38	25	18	38	17	A-6(7)	CL
100	96	93	88	76	57	50	38	25	18	34	15	A-6-7	CL
-------	-------	100	99	89	60	45	24	11	8	29	10	A-4(5)	CL
-------	100	99	96	86	64	51	35	24	19	48	28	A-7-6(14)	CL
-------	-------	100	99	93	30	22	14	9	9	NP	NP	A-2-4(0)	SM
-------	-------	100	99	88	27	21	10	5	3	NP	NP	A-2-4(0)	SM
-------	100	99	99	91	26	20	13	7	4	NP	NP	A-2-4(0)	SM
-------	100	99	96	83	22	15	9	8	6	NP	NP	A-2-4(0)	SM
-------	100	99	98	83	28	23	14	6	3	NP	NP	A-2-4(0)	SM
-------	-------	100	99	87	23	20	13	9	6	NP	NP	A-2-4(0)	SM
-------	100	99	98	82	13	10	8	6	4	NP	NP	A-2-4(0)	SM
-------	-------	100	99	90	41	29	13	8	6	27	7	A-4(1)	SM-SC
-------	-------	-------	100	89	25	22	16	11	9	NP	NP	A-2-4(0)	SM
100	97	94	89	67	6	5	5	4	4	NP	NP	A-3(0)	SP
[6] 85	70	49	34	22	4	3	2	1	1	NP	NP	A-1-a(0)	GW
-------	-------	-------	100	99	96	69	31	17	13	38	16	A-6(10)	CL
-------	-------	-------	-------	100	98	72	40	31	26	35	15	A-6(10)	CL
-------	-------	-------	-------	100	99	64	25	18	15	28	2	A-4(8)	ML
-------	-------	-------	-------	-------	100	57	13	10	8	NP	NP	A-4(8)	ML
-------	-------	-------	-------	100	98	58	18	13	10	NP	NP	A-4(8)	ML
-------	-------	-------	100	99	97	92	77	44	31	48	28	A-7-6(17)	CL
-------	-------	-------	-------	100	98	64	24	15	11	39	16	A-6(10)	CL
-------	-------	-------	-------	100	97	65	27	18	15	27	3	A-4(8)	ML
-------	-------	-------	-------	100	98	91	72	40	30	40	23	A-6(13)	CL
-------	-------	-------	100	98	96	94	84	54	39	53	32	A-7-6(19)	CH
-------	-------	-------	-------	100	94	54	16	11	9	31	12	A-6(9)	CL
-------	-------	-------	-------	100	96	59	21	16	14	30	7	A-4(8)	ML-CL
-------	-------	-------	-------	100	95	59	23	19	16	NP	NP	A-4(8)	ML
-------	-------	-------	-------	100	97	53	12	11	9	NP	NP	A-4(8)	ML

TABLE 5.—*Engineering*

Soil name and location	Parent material	North Dakota State University report No.	Depth from surface	Moisture density [1] Maximum dry density	Moisture density [1] Optimum moisture
		NDH-	In.	Lb./cu. ft.	Pct.
Hamerly loam: 390 ft. E. and 55 ft. S. of NW. corner of sec. 4, T. 156 N., R. 58 W. (Modal)	Glacial till.	130	0–7	92	22
		131	14–25	101	20
		132	31–46	104	18
		133	46–60	107	18
150 ft. W. of NE. corner of sec. 4, T. 155 N., R. 58 W. (Thin surface layer)	Glacial till.	124	5–10	110	17
		125	15–35	114	14
		126	35–60	117	13
100 ft. W. and 200 ft. N. of the SE. corner of sec. 23, T. 155 N., R. 59 W. (Moderately saline)	Glacial till.	127	0–8	95	22
		128	14–26	105	18
		129	39–60	111	16
Hegne silty clay: 250 ft. N. and 560 ft. E. of W¼ corner of sec. 31, T. 157 N., R. 51 W. (Modal)	Lacustrine clay.	90	0–6	88	27
		91	14–18	92	26
		92	18–31	100	22
		93	31–41	98	24
		94	41–60	102	18
400 ft. S. and 300 ft. E. of W¼ corner of sec. 24, T. 158 N., R. 52 W. (Clay substratum)	Lacustrine clay.	77	0–9	93	24
		78	19–33	101	22
		79	44–60	85	25
700 ft. E. and 100 ft. S. of NW. corner of sec. 23, T. 158 N., R. 51 W. (Light silty clay surface layer)	Lacustrine clay.	73	0–10	99	22
		74	10–25	109	17
		75	25–40	100	22
		76	40–60	97	22
Vang loam: 250 ft. E. and 250 ft. S. of W¼ corner of sec. 26, T. 155 N., R. 56 W.	Water-deposited shaly and granitic gravel.	101	14–25	88	30
		102	25–39	88	28
		103	39–47	87	27

[1] Based on AASHO Designation T 99–57, Method A and C (*1*).

[2] Mechanical analyses according to AASHO Designation T 88 (*1*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

test data—Continued

Mechanical analysis [2]										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—						Percentage smaller than—						AASHO	Unified [3]
¾ in.	⅜ in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
100	96	95	92	83	61	44	21	10	7	44	17	A-7-6(9)	ML-CL
-------	100	98	94	84	65	57	41	26	18	41	21	A-7-6(11)	CL
100	99	97	93	78	57	50	38	24	17	35	17	A-6(7)	CL
100	96	93	88	76	56	49	37	24	18	32	15	A-6(6)	CL
100	98	97	94	86	64	54	36	24	18	36	20	A-6(10)	CL
100	99	96	91	77	53	47	35	25	19	30	16	A-6(6)	CL
100	98	95	90	79	54	50	37	25	20	26	13	A-6(5)	CL
100	96	95	93	86	67	51	29	19	15	41	19	A-7-6(10)	CL
[4] 97	96	94	90	76	58	53	38	22	16	44	27	A-7-6(12)	CL
100	97	94	91	79	57	52	41	26	20	34	18	A-6(8)	CL
-------	-------	-------	-------	100	95	75	43	26	19	52	27	A-7-6(17)	CH
-------	-------	-------	100	99	97	76	44	25	20	59	36	A-7-6(20)	CH
-------	-------	-------	-------	100	98	91	73	43	30	47	28	A-7-6(17)	CL
-------	-------	-------	-------	100	97	95	75	55	39	53	34	A-7-6(19)	CH
-------	-------	-------	-------	100	97	94	87	55	36	53	31	A-7-6(19)	CH
-------	-------	-------	-------	100	97	78	52	30	22	48	27	A-7-6(16)	CL
-------	-------	-------	-------	100	98	93	81	52	34	53	34	A-7-6(19)	CH
-------	-------	-------	-------	-------	100	93	84	79	73	99	74	A-7-6(20)	CH
-------	-------	-------	-------	100	99	85	57	41	35	44	12	A 7-5(10)	ML
-------	-------	-------	-------	-------	100	92	68	41	32	40	25	A-6(14)	CL
-------	-------	-------	-------	-------	100	95	83	55	41	54	19	A-7-5(19)	MH
-------	-------	-------	100	99	97	93	84	53	36	52	34	A-7-6(18)	CH
100	99	98	96	71	41	36	28	14	9	37	12	A-6(2)	SM-SC
[7] 98	97	96	95	69	56	43	20	9	6	34	0	A-4(4)	ML
100	99	99	99	60	31	25	17	10	7	32	10	A-2-4(0)	SM-SC

[3] Based on the Unified Soil Classification System (*9*). Soil Conservation Service and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification. An example of the borderline classification obtained by this use is ML-CL.

[4] 100 percent passed the 1-inch sieve.

[5] NP=Nonplastic.

[6] 100 percent passed the 1½-inch sieve, and 91 percent the 1-inch sieve.

[7] 100 percent passed the 1½-inch sieve, and 98 percent the 1-inch sieve.

TABLE 6.—*Estimated engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soil in referring to other series that appear

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA	Unified	AASHO
	Feet	*Inches*			
Antler: An, Ao	1–4	0–13	Clay loam	CL	A–7
		13–33	Clay loam	CL	A–7
		33–60	Clay loam	CL	A–6
*Arveson:					
Fine sandy loam: As	0–3	0–10	Fine sandy loam	SM	A–2
(For Fossum part of As, see Fossum fine sandy loam.)		10–22	Loam	ML	A–4
		22–48	Fine sandy loam	SM	A–2
		48–60	Silt	ML	A–4
Loam: At	0–3	0–10	Loam	ML	A–4
(For Fossum part of At, see Fossum loam.)		10–22	Loam	ML	A–4
		22–48	Fine sandy loam	SM	A–2
Arvilla: AuA, AuB	5+	0–19	Sandy loam	SM	A–2
		19–26	Sand	SM	A–2
		26–60	Coarse sand	SP or SM	A–1
*Barnes: BaC, BaC2, BbD2, Be, BgC, BhD, BkB, BkB2, BlA, BlC.	5+	0–8	Loam	CL or ML–CL	A–4 or A–6
(For Buse part of BbD2 and Be, see Buse series; for Renshaw part of BgC, see Renshaw series; for Sioux part of BhD, see Sioux series; and for Svea part of BkB, BkB2, BlA, and BlC, see Svea series.)		8–19	Loam, clay loam	CL or ML–CL	A–4 or A–6
		19–60	Loam, very fine sandy loam.	CL	A–6
Bearden:					
Bm	3–5	0–6	Silt loam	CL	A–6
		6–20	Silt loam	CL	A–6
		20–60	Silty clay loam	CL	A–7
BnA, BnC, Bo	3–5	0–9	Silty clay loam	CL	A–7
		9–20	Silty clay loam	CL	A–7
		20–60	Silty clay loam, silty clay, clay.	CL	A–7
Br	3–5	0–15	Silty clay loam	CL	A–7
		15–24	Silty clay loam	CL	A–7
		24–60	Silt loam	CL	A–6
Bs	3–5	0–40	Silty clay loam	CL	A–7
		40–60	Gravel	GM	A–2
Bt	3–5	0–8	Silty clay	CH	A–7
		8–15	Silty clay	CH	A–7
		15–60	Silty clay loam	CL	A–7
Benoit: Bu	0–3	0–6	Loam	CL	A–6
		6–19	Clay loam	CL	A–6
		19–31	Sandy loam	SM	A–2
		31–50	Gravelly coarse sand	SP or SM	A–1
Borup: Bv	0–5	0–18	Silt loam	ML–CL	A–4
		18–41	Very fine sandy loam.	ML–CL	A–4
		41–60	Silty clay loam	CL	A–7
*Brantford: BwB, BwC	5+	0–20	Loam	ML	A–4
(For Vang pa rt of these units, see Vang seri (		20–60	Gravel	GM	A–1

properties of the soils

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for in the first column of this table]

Percentage passing sieve— No. 4	No. 10	No. 200	Permeability	Available water capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
			Inches per hour	*Inches per inch of soil*	*pH*			
100	100	85–95	0.63–2.0	0.20	7.4–7.8	None	Low	High.
100	100	70–80	0.20–0.63	.20	7.9–8.4	None	Low	High.
95–100	85–95	70–80	0.20–0.63	.17	7.9–8.4	Slight	Low	Moderate.
95–100	85–95	25–35	0.63–2.0	.14	7.4–7.8	Slight	Low	Low.
100	90–100	60–75	0.63–2.0	.16	7.9–8.4	Slight	Low	Low.
100	90–100	20–40	2.0–6.3	.14	7.9–8.4	Slight to moderate.	Low	Low.
100	100	85–100	0.20–0.63	.20	7.9–8.4	Slight to moderate.	Low	Low.
100	90–100	60–75	0.63–2.0	.16	7.4–7.8	None to slight.	Low	Low.
100	90–100	60–75	0.63–2.0	.16	7.9–8.4	Slight	Low	Low.
100	90–100	20–40	2.0–6.3	.12	7.9–8.4	Slight to moderate.	Low	Low.
95–100	85–95	25–35	0.63–2.0	.15	6.6–7.3	None	Low	Low.
95–100	85–95	15–25	2.0–6.3	.04	7.4–7.8	None	Low	Low.
80–95	50–70	5–15	>6.3	.03	7.4–7.8	None	Low	Low.
100	90–100	60–75	0.63–2.0	.18	7.4–7.8	None	Low	Low to moderate.
100	90–100	60–75	0.63–2.0	.18	7.9–8.4	None	Low	Low to moderate.
95–100	85–95	70–80	0.20–0.63	.16	7.9–8.4	Moderate	Low	Moderate.
100	100	70–90	0.63–2.0	.22	7.4–7.8	None	Low	Moderate.
100	100	70–90	0.63–2.0	.20	7.9–8.4	Slight	Low	Moderate.
100	100	85–95	0.20–0.63	.20	7.9–8.4	Slight	Low	High.
100	100	85–95	0.63–2.0	.22	7.4–7.8	None	Low	High.
100	100	85–95	0.63–2.0	.20	7.9–8.4	Slight	Low	High.
100	100	85–95	0.20–0.63	.20	7.9–8.4	Slight	Low	High.
100	100	85–95	0.63–2.0	.22	7.9–8.4	Moderate	Moderate	High.
100	100	85–95	0.63–2.0	.20	7.9–8.4	Moderate	Low	High.
100	100	70–90	0.20–0.63	.20	8.5–9.0	Moderate	Low	Moderate.
100	100	85–95	0.63–2.0	.22	7.4–7.8	Slight	Low	High.
60–80	45–65	10–20	>6.3	.03	7.9–8.4	Slight	Low	Low.
100	100	90–95	0.63–2.0	.22	7.4–7.8	None	Low	High.
100	100	90–95	0.20–0.63	.20	7.9–8.4	Slight	Low	High.
100	100	85–95	0.20–0.63	.20	7.9–8.4	Slight	Low	High.
100	95–100	65–85	0.20–0.63	.20	7.4–8.4	Slight	Low	Moderate.
95–100	85–95	70–80	0.20–0.63	.18	7.4–7.8	Slight	Low	Moderate.
95–100	85–95	25–35	0.20–0.63	.15	7.9–8.4	Slight	Low	Low.
80–95	80–70	5–15	>6.3	.03	7.9–8.4	Slight	Low	Low.
100	100	70–90	0.63–2.0	.18	7.9–8.4	None	Low	Low.
100	100	60–90	0.63–2.0	.16	7.9–8.4	Slight	Low	Low.
100	100	85–95	0.20–0.63	.22	7.4–8.4	Slight	Low	High.
90–100	80–90	60–75	0.63–2.0	.17	6.6–7.3	None	Low	Low.
60–80	40–50	10–20	>6.3	.03	6.6–7.3	None	Low	Low.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA	Unified	AASHO
	Feet	*Inches*			
*Buse: ByC, ByD, ByE (For Barnes part of these units, see Barnes series.)	5+	0–7	Loam	CL	A–6
		7–23	Loam	CL	A–6 or A–7
		23–60	Clay loam	CL	A–6
Cashel: CaA, CaB, CcE	5+	0–14	Silty clay	CH	A–7
		14–60	Silty clay	CH	A–7
Cavour: Cd	3–5	0–6	Clay loam	CL	A–7
		6–14	Clay	CH	A–7
		14–30	Silty clay	CH	A–7
		30–40	Clay	CH	A–7
		40	Shale	MH	------------
Coe: Ce	5+	0–5	Loam	ML	A–4
		5–60	Gravel and sand	GM	A–1
Colvin:					
Cf	0–5	0–12	Silt loam	CL	A–6
		12–60	Silty clay loam	CL	A–7
Ch	0–5	0–14	Silty clay loam	CL	A–6
		14–30	Silt loam	ML-CL	A–4
		30–60	Silty clay loam, clay	CL	A–6
Co	0–5	0–11	Silty clay loam	CL	A–6
		11–60	Silty clay loam	CL	A–6
Cresbard (Mapped only in complexes with Hamerly and Svea soils).	5+	0–9	Loam	ML	A–4
		9–16	Clay	CL	A–6
		16–60	Clay loam	CL	A–6
Divide: DdA	3–5	0–8	Loam	ML	A–4
		8–20	Clay loam	ML	A–4
		20–60	Gravel	GM	A–1
Edgeley: EbA, EbB, EbC	5+	0–5	Loam	CL	A–6
		5–25	Clay loam	CL	A–6
		25–46	Shaly clay loam	CL	A–6
		46	Shale.		
Embden:					
EmA, EmB, EmC	5+	0–11	Sandy loam	SM	A–2
		11–24	Fine sandy loam	SM	A–2, A–4
		24–60	Loamy sand	SM	A–2
EnA	5+	0–6	Loam	ML	A–4
		6–16	Loam	ML	A–4
		16–25	Fine sandy loam	SM	A–2
		25–60	Loamy fine sand	SM	A–2
*Fairdale: Fa, FaB, Fd, Fe (For the LaPrairie part of Fe, see LaPrairie silt loam and LaPrairie silty clay loam.)	5+	0–60	Silt loam	ML or CL	A–4 or A–6
Fargo:					
Silty clay: FfA	0–5	0–22	Silty clay	CH	A–7
		22–60	Silty clay	CH	A–7
Silty clay, depressional: Fg	0–5	0–15	Silty clay	CH	A–7
		15–36	Silty clay	CH	A–7
		36–60	Silty clay	CH	A–7
*Fargo-Hegne silty clays: FhA, FhB (For Hegne part of these units, see Hegne silty clay.)	0–5	0–60	Silty clay	CH	A–7

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
No. 4	No. 10	No. 200						
			Inches per hour	*Inches per inch of soil*	*pH*			
95–100	95–100	60–75	0. 63–2. 0	. 20	7. 9–8. 4	Slight	Low	Moderate.
95–100	95–100	60–75	0. 63–2. 0	. 17	6. 6–7. 3	None	Low	Moderate to high.
95–100	85–95	70–80	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	Moderate.
100	100	90–95	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	High.
100	100	70–80	0. 06–0. 20	. 14	7. 9–8. 4	Slight	High	High.
100	100	75–95	0. 06–0. 20	. 14	7. 9–9. 0	Moderate	High	High.
100	100	75–95	0. 06–0. 20	. 14	7. 9–9. 0	Moderate	Moderate	High.
100	100	75–95	0. 20–0. 63	. 14	7. 9–9. 0	Severe	Moderate	High.
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90–100	80–90	60–75	0. 63–2. 0	. 14	6. 6–7. 3	None	Low	Low.
50–70	30–50	0–15	>6. 3	. 03	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 22	7. 4–7. 8	None	Low	Moderate.
100	100	85–95	0. 20–0. 63	. 20	7. 9–8. 4	Slight	Low	High.
100	100	90–95	0. 63–2. 0	. 22	7. 4–7. 8	None	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	7. 9–8. 4	Slight	Low	Low.
100	100	90–95	0. 20–0. 63	. 18	7. 9–8. 4	Slight	Low	Moderate.
100	100	90–95	0. 2–6. 3	. 22	7. 4–8. 4	None	Low	Moderate.
100	100	90–95	0. 63–2. 0	. 18	7. 4–8. 4	Slight	Low	Moderate.
95–100	90–100	60–75	0. 63–2. 0	. 20	6. 6–7. 3	None	Moderate	Low.
95–100	90–100	60–80	0. 20–0. 63	. 20	7. 4–8. 4	None	Moderate	Moderate.
95–100	90–100	60–80	0. 20–0. 63	. 17	7. 4–7. 8	Moderate	Slight	Moderate.
95–100	90–100	50–65	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Low.
95–100	90–100	50–65	0. 63–2. 0	. 20	7. 9–8. 4	Slight	Low	Low.
60–80	45–65	10–20	>6. 3	. 03	7. 9–8. 4	Slight	Low	Low.
95–100	90–100	60–75	0. 63–2. 0	. 18	6. 6–7. 3	None	Low	Moderate.
95–100	85–95	70–80	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Moderate.
90–100	80–90	70–80	0. 20–0. 63	. 16	7. 4–7. 8	None	Low	Moderate.
95–100	90–100	25–35	2. 0–6. 30	. 14	6. 6–7. 3	None	Low	Low.
100	90–100	20–40	2. 0–6. 30	. 14	7. 4–7. 8	None	Low	Low.
95–100	90–100	15–30	2. 0–6. 30	. 09	7. 4–8. 4	None	Low	Low.
100	90–100	50–65	0. 63–2. 0	. 15	6. 6–7. 3	None	Low	Low.
100	90–100	50–65	0. 63–2. 0	. 15	7. 4–7. 8	None	Low	Low.
100	90–100	20–35	2. 0–6. 30	. 14	7. 4–8. 4	None	Low	Low.
95–100	90–100	15–30	2. 0–6. 30	. 09	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Low to moderate.
100	100	90–100	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	90–100	0. 06–0. 20	. 18	7. 9–8. 4	None	Low	High.
100	100	90–100	0. 20–0. 63	. 20	6. 6–7. 3	None	Low	High.
100	100	90–100	0. 06–0. 20	. 20	7. 4–7. 8	None	Low	High.
100	100	90–100	0. 06–0. 20	. 18	7. 4–7. 8	None	Low	High.
100	100	90–100	0. 06–0. 63	. 20	7. 4–7. 8	None	Low	High.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA	Unified	AASHO
Fossum:	*Feet*	*Inches*			
Fine sandy loam (Mapped only in a complex with Arveson fine sandy loam.)	0–3	0–9	Fine sandy loam	SM	A–2
		9–19	Sandy loam	SM	A–2
		19–54	Fine sand	SP–SM	A–2
Loam (Mapped only in a complex with Arveson loam.)	0–3	0–9	Loam	CL	A–4 or A–6
		9–19	Sandy loam	SM	A–2–4
		19–54	Fine sand	SP–SM	A–2
Gardena: GaA, GaB	5+	0–11	Silt loam	ML	A–4
		11–20	Silt loam	ML	A–4
		20–60	Very fine sandy loam	ML–CL	A–4
Gilby:					
Gb, Gh	1–4	0–10	Loam	CL	A–6
		10–33	Loam	CL	A–6
		33–60	Clay loam	CL	A–6
Ge	1–4	0–8	Loam	CL	A–6
		8–28	Loam	CL	A–6
		28–60	Clay loam	CL	A–6
Glyndon:					
GlA, GlB	2–5	0–28	Silt loam	ML	A–4
		28–55	Very fine sandy loam	ML–CL	A–4
Gm	2–5	0–8	Silt loam	ML	A–4
		8–28	Silt loam	ML	A–4
		28–55	Very fine sandy loam	ML–CL	A–4
*Grano: Gr, Gs (For Hegne part of Gs, see Hegne silty clay.)	0–3	0–24	Silty clay	CH	A–7–6
		24–60	Silty clay	CH	A–7–6
*Hamar:					
Loamy sand: Ha (For Ulen part of this unit, see Ulen loamy sand.)	0–3	0–28	Loamy sand	SM	A–2
		28–60	Sand	SM	A–2
Sandy loam: Hd	0–3	0–6	Sandy loam	SM	A–2
		6–20	Loamy fine sand	SM	A–2
		20–54	Loamy fine sand	SM	A–2
*Hamerly: He, HgA, HgB (For Cresbard part of He, see Cresbard series. For Svea part of HgA and HgB, see Svea series.)	2–5	0–14	Loam	ML–CL	A–4
		14–25	Clay loam	CL	A–7
		25–60	Clay loam	CL	A–6
Hattie: Hh	5+	0–20	Silty clay	CH	A–7
		20–60	Silty clay	CH	A–7
Hecla: HlA, HlB	4–5	0–32	Loamy sand	SM	A–1
		32–55	Sand	SM	A–1
*Hegne:					
Silty clay: HmA, HmB (For Fargo part of these mapping units, see Fargo silty clay.)	3–5	0–14	Silty clay	CH	A–7
		14–31	Silty clay	CH	A–7
		31–60	Clay	CH	A–7
Silty clay, saline: Hn	3–5	0–6	Silty clay	CH	A–7
		6–60	Silty clay	CH	A–7
Silty clay, strongly saline-alkali: Hs	3–5	0–6	Silty clay	CH	A–7
		6–60	Silty clay	CH	A–7

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
No. 4	No. 10	No. 200						
			Inches per hour	*Inches per inch of soil*	*pH*			
95–100	85–95	25–35	0. 63–2. 0	. 14	7. 4–7. 8	None to slight.	Low	Low.
95–100	85–95	25–35	0. 63–2. 0	. 14	7. 4–7. 8	None to slight.	Low	Low.
100	100	10–20	2. 0–6. 3	. 07	7. 9–8. 4	None	Low	Low.
100	90–100	60–75	0. 63–2. 0	. 14	7. 4–7. 8	None to slight	Low	Low to moderate.
95–100	85–95	25–35	0. 63–2. 0	. 14	7. 4–7. 8	None to slight	Low	Low.
100	100	10–20	2. 0–6. 3	. 08	7. 9–8. 4	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 17	7. 4–7. 8	None	Low	Low.
100	100	60–75	0. 63–2. 0	. 17	7. 4–7. 8	None	Low	Moderate.
100	100	60–75	0. 63–2. 0	. 17	7. 9–8. 4	Slight	Low	Moderate.
90–95	90–95	70–80	0. 20–0. 63	. 15	7. 9–8. 4	Slight	Low	Moderate.
100	100	60–75	0. 63–2. 0	. 17	7. 4–7. 8	Slight	Low	Moderate.
100	100	60–75	0. 63–2. 0	. 17	7. 9–8. 4	Moderate	Low	Moderate.
90–95	90–95	70–80	0. 20–0. 63	. 15	7. 9–8. 4	Slight	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 16	7. 9–8. 4	None	Low	Low.
100	100	100	0. 63–2. 0	. 20	7. 4–7. 8	Moderate	Low	Low.
100	100	70–90	0. 63–2. 0	. 20	7. 9–8. 4	Moderate	Low	Low.
100	100	70–90	0. 63–2. 0	. 16	7. 9–8. 4	Slight	Low	Low.
100	100	90–100	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	90–100	0. 06–0. 20	. 18	7. 4–7. 8	Moderate	Low	High.
100	90–100	25–35	2. 0–6. 3	. 12	7. 4–7. 8	None	Low	Low.
100	90–100	5–25	2. 0–6. 3	. 08	6. 6–7. 8	None	Low	Low.
100	90–100	25–35	0. 63–2. 0	. 14	7. 4–7. 8	None	Low	Low.
100	90–100	25–35	2. 0–6. 3	. 09	7. 4–7. 8	None	Low	Low.
100	100	25–35	2. 0–6. 3	. 14	7. 9–8. 4	Slight	Low	Low.
95–100	90–100	60–75	0. 63–2. 0	. 18	7. 9–8. 4	None	Low	Low.
95–100	90–100	60–75	0. 63–2. 0	. 18	7. 9–8. 4	None	Low	High.
90–100	85–95	55–75	0. 06–0. 20	. 16	7. 9–8. 4	None	Low	Moderate.
100	100	90–100	0. 20–0. 63	. 21	7. 4–7. 8	None	Low	High.
100	100	90–100	0. 06–0. 20	. 18	7. 8–8. 4	Noue	Low	High.
100	100	15–25	2. 0–6. 3	. 12	6. 6–7. 3	None	Low	Low.
100	100	10–20	2. 0–6. 3	. 08	6. 6–7. 3	None	Low	Low.
100	100	90–100	0. 63–2. 0	. 21	7. 9–8. 4	None	Low	High.
100	100	90–100	0. 20–0. 63	. 21	7. 9–8. 4	None	Low	High.
100	100	90–100	0. 06–0. 20	. 18	7. 9–8. 4	Slight	Low	High.
100	100	90–100	0. 20–0. 63	. 21	7. 9–8. 4	Moderate	High	High.
100	100	90–100	0. 06–0. 20	. 18	7. 9–8. 4	Moderate	High	High.
100	100	90–100	0. 20–0. 63	. 21	7. 9–8. 4	Severe	High	High.
100	100	90–100	0. 06–0. 20	. 18	7. 9–8. 4	Severe	High	High.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA	Unified	AASHO
	Feet	*Inches*			
Kloten: Kn	5+	0–5	Loam	ML–CL	A–4
		5–13	Clay loam	CL	A–6
		13	Shale rock.		
Lamoure: La	2–5	0–60	Silty clay loam	CL	A–7
Lankin:					
LeA	2–5	0–7	Loam	ML	A–4
		7–16	Loam	ML	A–4
		16–60	Clay loam	CL	A–6
Lk	2–5	0–14	Clay loam	CL	A–6
		14–24	Clay loam	CL	A–6
		24–60	Clay loam	CL	A–6
LnA, LnB (For Svea soils in these units, see Svea series.)	2–5	0–10	Loam	ML	A–4
		10–18	Loam	ML	A–4
		18–34	Clay loam	CL	A–6
		34–49	Sandy loam	SM	A–1
		49–58	Loam	ML	A–4
LaPrairie:					
Silt loam: Lp	5+	0–60	Silt loam, silty clay loam.	CL	A–6
Silty clay loam: Lr	5+	0–21	Silty clay loam	CL	A–7
		21–60	Silty clay laom	CL	A–7
*Ludden:					
Lu	0–5	0–60	Silty clay	CH	A–7
Ly (For Ryan part of this unit, see the Ryan series.)	0–5	0–60	Silty clay	CH	A–7
*Maddock: Mk3 (For Hecla part of this unit, see Hecla series.)	5+	0–60	Light sandy loam, loamy sand, and sand.	SP–SM	A–2
Manfred: Mn	0–5	0–13	Silty clay loam	CL	A–6
		13–23	Silty clay loam	CL	A–6
		23–60	Sandy clay loam, clay loam.	CL	A–6
Ojata: Oa	2–4	0–5	Silty clay loam	CL	A–7
		5–12	Silty clay loam	CH	A–7
		12–60	Silty clay loam	CH	A–7
Overly:					
OeA	5+	0–12	Silt loam	ML–CL	A–4
		12–24	Silty clay loam	CL	A–7
		24–46	Silty clay loam	CL	A–7
		46–60	Silty clay loam	CL	A–7
OlA, OlB, OlC	5+	0–17	Silty clay loam	CL	A–7
		17–38	Silty clay loam	CL	A–7
		38–60	Silty clay, silty clay loam.	CH	A–7
Om	5+	0–17	Silty clay loam	CL	A–7
		17–24	Silty clay loam	CL	A–7
		24–30	Silty clay loam	CL	A–7
		30–42	Silty clay loam	CL	A–7
		42–60	Silt loam	ML–CL	A–4
OvA, Ow	5+	0–17	Silty clay	CH	A–7
		17–40	Silty clay loam	CL	A–7
		40–60	Silty clay loam	CL	A–7

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
No. 4	No. 10	No. 200						
			Inches per hour	*Inches per inch of soil*	*pH*			
95–100	90–100	60–75	0. 63–2. 0	. 18	6. 6–7. 3	None	Low	Low.
95–100	90–100	70–80	0. 20–0. 63	. 17	7. 4–7. 8	None	Low	Low.
100	100	85–95	0. 20–0. 63	. 22	7. 4–7. 8	None to moderate.	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Moderate.
100	100	70–90	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	Moderate.
100	100	70–90	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 17	6. 6–7. 3	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 17	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	Moderate.
100	100	25–35	0. 63–2. 0	. 10	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 20–0. 63	. 15	7. 4–7. 8	None	Low	Low.
100	100	70–90	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Moderate.
100	100	85–95	0. 63–2. 0	. 22	7. 4–7. 8	None	Low	High.
100	100	85–95	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 20–0. 63	. 19	7. 4–8. 4	Slight	Low	High.
100	100	90–95	0. 20–0. 63	. 19	7. 4–9. 0	Severe	Moderate	High.
100	100	10–20	2. 0–6. 3	. 10	6. 6–7. 3	None	Low	Low.
100	100	85–95	0. 63–2. 0	. 22	7. 4–7. 8	Slight	Low	Moderate.
100	100	85–95	0. 63–2. 0	. 22	7. 9–9. 0	Slight	Low	Moderate.
95–100	95–100	70–80	0. 06–0. 20	. 18	7. 9–8. 4	Moderate	Low	Moderate.
100	100	90–95	0. 20–0. 63	. 12	7. 9–8. 4	Moderate	Moderate	High.
100	100	90–95	0. 06–0. 63	. 12	7. 9–9. 0	Very severe	High	High.
100	100	90–95	0. 06–0. 20	. 12	7. 9–9. 0	Very severe	High	High.
100	100	70–90	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
100	100	90–95	0. 20–0. 63	. 22	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 20–0. 63	. 22	7. 9–8. 4	None	Low	High.
100	100	90–95	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 63–2. 0	. 22	6. 6–7. 3	None	Low	High.
100	100	90–95	0. 20–0. 63	. 22	7. 9–8. 4	None	Low	High.
100	100	90–95	0. 06–0. 20	. 18	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 63–2. 0	. 22	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 20–0. 63	. 22	7. 4–9. 4	None	Low	High.
100	100	90–95	0. 20–0. 63	. 22	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	70–90	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	Low.
100	100	90–95	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 20–9. 63	. 20	7. 4–7. 8	None	Low	High.
100	100	90–95	0. 06–0. 63	. 20	7. 4–7. 8	None	Low	High.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA	Unified	AASHO
	Feet	*Inches*			
*Parnell: Pa, Pt (For Tonka part of Pt, see Tonka series.)	0–5	0–19	Silty clay loam	CL	A–7
		19–37	Silty clay loam	CL	A–7
		37–60	Clay	CL	A–6
Perella: Pu	0–5	0–23	Silty clay loam	CH	A–7
		23–40	Silt loam	ML–CL	A–4
		40–60	Clay	CH	A–7
Rauville: Ra	0–3	0–20	Silt loam, loam	ML or CL	A–4 or A–6
		20–42	Gravelly sand	SM	A–1
Renshaw: ReA, ReB	5+	0–6	Loam	ML	A–4
		6–18	Sandy clay loam, gravelly loam.	ML	A–4
		18–60	Gravel	GW	A–1
Rockwell: Ro	1–2	0–8	Fine sandy loam	SM, ML	A–4
		8–19	Loamy fine sand	SM	A–1
		19–26	Fine sandy loam	SM, ML	A–4
		26–60	Clay loam	CL	A–6
Ryan (Mapped only in an undifferentiated unit with Ludden soils.)	3–5	0–3	Silty clay	CH	A–7
		3–28	Clay	CH	A–7
		28–60	Clay, silty clay	CH	A–7
*Sioux: Sr, SsE (For Renshaw part of these units, see Renshaw series.)	5+	0–8	Gravelly loam	ML or GM	A–4
		8–60	Gravel and sand	GW	A–1
*Svea: SuA, SvA (For Barnes part of SuA, see Barnes series. For Cresbard part of SvA, see Cresbard series.)	5+	0–8	Loam	ML	A–4
		8–19	Clay loam	CL	A–6
		19–26	Clay loam	CL	A–6
		26–60	Loam	CL	A–6
Tonka (Mapped only in an undifferentiated unit with Parnell soils.)	0–5	0–16	Silt loam	ML–CL	A–4
		16–26	Loam	ML	A–4
		26–42	Clay loam	CL	A–7
		42–60	Sandy clay, clay loam.	CL	A–7
Towner: ToA	2½–5	0–19	Sandy loam	SM	A–2
		19–31	Loamy sand	SM	A–2
		31–60	Clay loam	CL	A–6
Ulen:					
Loamy sand (Mapped only in an undifferentiated unit with Hamar loamy sand.)	3–5	0–7	Loamy sand	SM	A–1
		7–19	Sandy loam	SM	A–2
		19–60	Loamy fine sand	SM	A–1
Sandy loam: Un	3–5	0–15	Sandy loam	SM	A–2
		15–32	Loam	ML	A–4
		32–57	Loamy fine sand	SM	A–1
*Vallers:					
Va	1–5	0–6	Loam	ML–CL	A–4
		6–15	Clay loam	CL	A–7
		15–60	Clay loam	CL	A–7
Vh, Vm (For Hamerly part of these units, see Hamerly series.)	1–5	0–6	Loam	ML–CL	A–4
		6–15	Clay loam	CL	A–7
		15–60	Clay loam, sandy clay.	CL	A–7

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
No. 4	No. 10	No. 200						
			Inches per hour	*Inches per inch of soil*	*pH*			
100	100	90–95	0. 63–2. 0	. 22	6. 6–7. 3	None	Low	High.
100	100	90–95	0. 20–0. 63	. 22	6. 6–7. 3	None	Low	High.
95–100	95–100	70–80	0. 96–0. 20	. 22	7. 4–7. 8	Slight	Low	Moderate.
100	100	90–95	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	High.
100	100	70–90	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	Low.
100	100	90–95	0. 06–0. 63	. 18	7. 4–7. 8	None	Low	High.
100	100	60–75	0. 63–2. 0	. 20	7. 4–7. 8	Slight	Low	Low to moderate.
79–80	60–70	5–20	6. 3–20. 0	. 08	7. 4–7. 8	Slight	Low	Low.
100	100	60–75	0. 63–2. 0	. 17	6. 6–7. 3	None	Low	Low.
100	100	70–80	0. 63–2. 0	. 17	6. 6–7. 3	None	Low	Low.
30–40	10–20	0–10	>6. 3	. 02	6. 6–7. 8	None	Low	Low.
100	100	40–55	2. 0–6. 3	. 15	6. 6–7. 3	None	Low	Low.
100	100	10–20	2. 0–6. 3	. 12	7. 4–7. 8	None	Low	Low.
100	100	40–55	2. 0–6. 3	. 15	7. 4–7. 8	None	Low	Low.
90–100	80–100	70–80	0. 20–0. 63	. 18	7. 4–7. 8	Slight	Low	Moderate.
100	100	90–100	0. 20–0. 63	. 21	6. 1–6. 5	None	High	High.
100	100	90–100	0. 06–0. 20	. 16	7. 9–8. 4	Very severe	High	High.
100	100	90–100	0. 06–0. 20	. 16	7. 9–8. 4	Very severe	Moderate	High.
70–90	55–75	40–60	0. 63–2. 0	. 14	6. 6–7. 3	None	Low	Low.
30–50	20–30	5–15	>6. 3	. 02	7. 4–7. 8	None	Low	Low.
100	90–100	60–75	0. 63–2. 0	. 18	6. 6–7. 3	None	Low	Low.
100	90–100	70–80	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Moderate.
95–100	85–95	70–80	0. 63–2. 0	. 18	7. 4–7. 8	None	Low	Moderate.
95–100	85–95	70–80	0. 20–0. 63	. 16	7. 4–7. 8	None	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	6. 1–6. 5	None	Low	Low.
100	90–100	60–75	0. 63–2. 0	. 18	6. 1–6. 5	None	Low	Low.
90–100	90–100	70–80	0. 20–0. 63	. 18	6. 1–7. 3	None	Low	High.
90–100	90–100	70–80	0. 06–0. 63	. 18	7. 4–7. 8	None	Low	High.
100	100	25–35	2. 0–6. 3	. 14	6. 6–7. 8	None	Low	Low.
100	100	20–30	2. 0–6. 3	. 10	7. 4–7. 8	None	Low	Low.
100	100	70–80	0. 20–0. 63	. 18	7. 4–7. 8	None	Low	Moderate.
100	100	15–25	0. 63–2. 0	. 10	7. 4–7. 8	None	Low	Low.
100	100	25–35	0. 63–2. 0	. 15	7. 9–8. 4	None	Low	Low.
100	100	15–25	2. 0–6. 3	. 10	8. 5–9. 0	None	Low	Low.
100	100	25–35	0. 63–2. 0	. 15	7. 4–7. 8	None	Low	Low.
100	100	60–75	0. 63–2. 0	. 15	7. 9–8. 4	None	Low	Low.
100	100	15–25	2. 0–6. 3	. 10	7. 9–8. 4	None	Low	Low.
95–100	90–100	60–75	0. 20–0. 63	. 18	7. 9–8. 4	Moderate	Moderate	Low.
95–100	90–100	70–80	0. 20–0. 63	. 20	7. 9–8. 4	Moderate	Low	High.
90–100	90–100	70–80	0. 06–0. 63	. 16	7. 9–8. 4	Slight	Low	High.
95–100	90–100	60–75	0. 63–2. 0	. 18	7. 9–8. 4	Slight	Low	Low.
95–100	90–100	70–80	0. 20–0. 63	. 20	7. 9–8. 4	Slight	Low	High.
90–100	90–100	70–80	0. 06–0. 63	. 16	7. 9–8. 4	Slight	Low	High.

TABLE 6.—*Estimated engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA	Unified	AASHO
	Feet	*Inches*			
*Vang: VnA (For Brantford part of this unit, see Brantford series.)	5+	0–20	Loam	ML–CL	A–4
		20–30	Gravelly loam	ML	A–4
		30–48	Gravelly coarse sand.	SM	A–2
		48–60	Gravelly loamy sand.	SM	A–2
Wahpeton: Wa	5+	0–60	Silty clay	CH	A–7
Walsh:					
Loam: WhC	5+	0–10	Loam	ML–CL	A–4
		10–48	Silty clay loam	CL	A–6
		48–60	Loam	ML–CL	A–4
Loam, sand substratum: WlA, WlB	5+	0–39	Loam	ML–CL	A–4
		39–60	Gravelly coarse sand.	SP or SW	A–1
Clay loam: WnA	5+	0–6	Clay loam	CL	A–6
		6–24	Clay loam	CL	A–6
		24–60	Silty clay loam	CL	A–6
Silt loam: Wm	5+	0–10	Silt loam	ML	A–4
		10–48	Silty clay loam	CL	A–6
		48–60	Loam	ML or CL	A–4 or A–6
Waukon: WoB, WoD	5+	0–16	Loam	ML–CL	A–6
		16–44	Clay loam	CL	A–6
		44–60	Loam	CL	A–6
*Zell: ZgC, ZgE (For Gardena part of these units, see Gardena series.)	5+	0–21	Silt loam	ML	A–4
		21–36	Silty clay loam	CL	A–6
		36–60	Silty clay	CH	A–7

properties of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Salinity	Dispersion	Shrink-swell potential
No. 4	No. 10	No. 200						
			Inches per hour	*Inches per inch of soil*	*pH*			
100	100	60–75	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
75–100	60–90	50–80	0. 63–2. 0	. 16	6. 6–7. 3	None	Low	Low.
75–100	60–90	10 20	2. 0–6. 3	. 05	7. 4–7. 8	None	Low	Low.
75–100	60–90	10–20	2. 0–6. 3	. 04	7. 4–7. 8	None	Low	Low.
100	100	90–95	0. 20–2. 0	. 21	6. 6–7. 8	None	Low	High.
100	100	60–75	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
100	100	90–95	0. 63–2. 0	. 21	6. 6–7. 3	None	Low	Moderate.
95–100	95–100	80–90	0. 20–0. 63	. 18	7. 4–8. 4	None	Low	Low.
100	95–100	70–80	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
40–60	20–30	5–10	2. 0–6. 3	. 05	7. 4–8. 4	None	Low	Low.
100	100	70–80	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Moderate.
100	100	70–80	0. 20–0. 63	. 20	6. 6–7. 3	None	Low	Moderate.
100	100	80–90	0. 20–0. 63	. 18	7. 4–8. 4	None	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	6. 6–7. 3	None	Low	Low.
100	100	90–95	0. 63–2. 0	. 21	6. 6–7. 3	None	Low	Moderate.
95–100	95–100	80–90	0. 20–0. 63	. 18	7. 4–8. 4	None	Low	Low to moderate.
100	95–100	70–80	0. 63–2. 0	. 18	6. 1–6. 5	None	Low	Low.
100	100	80–90	0. 20–0. 63	. 20	6. 6–7. 3	None	Low	Moderate.
100	90–100	70–80	0. 20–0. 63	. 16	7. 4–7. 8	None	Low	Moderate.
100	100	70–90	0. 63–2. 0	. 20	7. 4–7. 8	None	Low	Low.
100	100	90–95	0. 20–0. 63	. 20	7. 4–7. 8	None	Low	Moderate.
100	100	90–95	0. 06–0. 63	. 18	7. 4–7. 8	None	Low	High.

TABLE 7.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils for referring to other series that appear

Soil series and map symbols	Suitability as a source of—			Soil limitations for sewage disposal by—	
	Topsoil	Sand and gravel	Road fill [1]	Septic tank filter fields	Sewage lagoons
Antler: An, Ao	Good to depth of 8 inches; fair to a depth of 16 inches.	Unsuitable: fair as a source of stone for riprap.	Poor: stones; high shrink-swell potential; frost hazard.	Severe: moderately slow permeability in substratum; stony.	Moderate: stones interfere with construction.
*Arveson: As, At (For Fossum part of As and At, see Fossum series.)	Good to depth of 15 inches.	Poor for sand; unsuitable for gravel.	Good	Severe: high water table.	Severe: moderately rapid permeability in substratum
Arvilla: AuA, AuB	Fair to depth of 19 inches.	Good as a source of sand; fair to poor for gravel.	Very good	Slight: danger of pollution.	Severe: rapid permeability in substratum.
Barnes: BaC, BaC2, BbD2, Be, BgC, BhD, BkB, BkB2, BlA, BlC. (For Buse part of BbD2 and Be, see Buse series; for Renshaw part of BgC, see Renshaw series; for Sioux part of BhD, see Soiux series, and for Svea part of BkB, BkB2, BlA, and BlC, see Svea series.	Good to depth of 5 inches; fair to a depth of 27 inches.	Unsuitable: fair as a source of stone for riprap.	Fair: low to moderate shrink-swell potential.	Severe: moderately slow permeability in substratum.	Slight: slope
Bearden: Bm, BnA, BnC, Bo	Good to depth of 6 inches; fair to a depth of 16 inches but high in lime.	Unsuitable	Poor: moderate to high shrink-swell potential; low shear strength; frost hazard.	Severe: moderately slow permeability; occasional high water table.	Moderate: fair stability as embankment material.
Br	Unsuitable	Unsuitable	Poor: moderrate to high shrink-swell potential; low shear strength; frost hazard.	Severe: moderately slow permeability; occasional high water table.	Moderate: fair stability as embankment material.
Bs	Fair to depth of 40 inches.	Unsuitable	Poor: high shrink-swell potential; frost hazard.	Severe: subject to flooding; high water table much of the time.	Severe: rapid permeability below depth of 40 inches; susceptible to seepage.
Bt	Good to depth of 8 inches; fair to a depth of 15 inches.	Unsuitable	Poor: high shrink-swell potential; low shear strength; frost hazard.	Severe: moderately slow permeability.	Moderate: fair stability as embankment material.

See footnote at end of table.

interpretations of the soils

in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions in the first column of this table]

Soil features affecting—						
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankments, dikes and levees	Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
Stones and boulders.	Soil features favorable.	Fair to good stability; high shrink-swell potential.	Stones interfere with construction.	Moderately slow permeability.	Stones interfere with construction.	High shrink-swell potential.
Seasonal high water table.	Moderately rapid permeability in substratum.	Moderately rapid permeability; susceptible to piping.	High water table.	High water table; poorly drained.	Not applicable.	High water table.
Soil features favorable.	Rapid permeability in substratum.	Moderate to high permeability where compacted.	Not applicable.	Low available water capacity; rapid permeability in substratum.	Shallow to sand.	Soil features favorable.
Topography.	Soil features favorable.	Soil features favorable.	Not applicable.	Topography.	Soil features favorable.	Moderate to low shrink-swell potential.
Frost heave.	Soil features favorable.	Fair stability; moderate to high shrink-swell potential.	Outlets difficult to obtain.	Moderately slow permeability.	Soil features favorable.	Moderate to hign shrink-swell potential; seasonal high water table.
Seasonal high water table.	Seasonal high water table.	Fair stability; susceptible to piping; moderate to high shrink-swell potential.	Outlets difficult to obtain.	Moderately slow permeability; moderate salinity.	Salinity; vegetation difficult to establish.	Moderate to high shrink-swell potential; seasonal high water table.
Subject to flooding.	Rapid permeability below depth of 40 inches.	High compacted permeability below depth of 40 inches.	Not applicable.	Soil features favorable; rapid permeability below depth of 40 inches.	Stability of side slopes.	Subject to flooding; high water table part of the time.
Frost heave.	Soil features favorable.	Fair to good stability; high shrink-swell potential.	Outlets difficult to obtain.	Moderately slow permeability.	Not applicable.	High shrink-swell potential.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil limitations for sewage disposal by—	
	Topsoil	Sand and gravel	Road fill [1]	Septic tank filter fields	Sewage lagoons
Benoit: Bu	Fair to depth of 6 inches.	Poor: excessive fine material; high water table.	Fair: frost hazard; good below a depth of 19 inches.	Severe: high water table.	Severe: rapid permeability in substratum; high water table.
Borup: Bv	Fair to depth of 15 inches.	Unsuitable	Fair: frost hazard; low shear strength.	Severe: high water table much of the time.	Moderate: fair stability as fill material; moderate permeability.
*Brantford: BwB, BwC (For Vang part of these units, see Vang series.)	Good to depth of 20 inches.	Poor: high content of shale.	Good	Slight: danger of pollution.	Severe: rapid permeability in substratum.
*Buse: ByC, ByD, ByE (For Barnes part of these units, see Barnes series.)	Good to depth of 7 inches; fair to a depth of 23 inches if fertilizer is used.	Unsuitable: fair as a source of stone for riprap.	Fair: moderate shrink-swell potential; low shear strength.	Severe: steep slopes; stones can interfere with excavation.	Severe: steep slopes.
Cashel: CaA, CaB, CcE	Good to depth of 14 inches; fair to a depth of 60 inches if fertilizer is used.	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: moderately slow permeability; flood hazard.	Moderate: flood hazard; stability as fill material; poor compaction characteristics.
Cavour: Cd	Unsuitable	Unsuitable	Poor: high shrink-swell potential; salts; low shear strength.	Severe: slow permeability.	Moderate: bedrock below depth of 40 inches.
Coe: Ce	Unsuitable	Poor: high content of shale.	Good	Slight: topography.	Severe: rapid permeability in substratum; topography.
Colvin: Cf, Ch, Co	Fair to depth of 11 inches; drainage needed to excavate.	Unsuitable	Poor: high shrink-swell potential.	Severe: moderate to moderately slow permeability; high water table.	Moderate: fair stability as fill material.
Cresbard (Mapped only in complexes with Hamerly and Svea soils.)	Fair to depth of 8 inches.	Unsuitable	Poor: moderate shrink-swell potential; salts; frost hazard.	Severe: moderately slow permeability in substratum and subsoil.	Moderate: salts in substratum; fair stability as embankment material.

See footnote at end of table.

interpretations of the soils—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
	Reservoir area	Embankments, dikes and levees				
High water table; seepage.	Rapid permeability in substratum.	High compacted permeability.	High water table; level topography.	High water table; poorly drained.	Not applicable	Not applicable.
High water table.	Soil features favorable.	Fair stability; susceptible to piping.	Outlets difficult to obtain.	High water table; poorly drained.	Not applicable	High water table.
Soil features favorable.	Rapid permeability in substratum.	Rapid rate of seepage in substratum; susceptible to piping.	Not applicable	Low available water capacity; shallow effective soil depth.	Erodible; vegetation difficult to establish.	Soil features favorable.
Steep slopes	Soil features favorable.	Fair to good stability.	Not applicable	Slope and topography.	Not applicable	Moderate shrink-swell potential; low shear strength; stones may interfere with excavation.
Subject to flooding.	Soil features favorable.	Clayey material; high shrink-swell potential; susceptible to cracking.	Soil features favorable; subject to flooding.	Subject to flooding; moderately slow permeability.	Soil features favorable.	Depth to bedrock; subject to frequent flooding.
Bedrock below depth of 40 inches.	Soil features favorable.	Impervious where compacted; high dispersion; high shrink-swell potential.	Bedrock below depth of 40 inches.	Strongly alkaline; slow permeability.	Not applicable	Soil features favorable; high content of salt.
Soil features favorable.	Rapid permeability.	High compacted permeability.	Not applicable	Shallow to gravel and sand; low available water capacity.	Not applicable	Soil features favorable.
High water table.	Soil features favorable.	Fair stability; high shrink-swell potential.	Outlets difficult to find; high water table.	High water table; poorly drained.	Not applicable	High water table.
Frost heave	Soil features favorable.	Fair stability; moderate shrink-swell potential.	Not applicable	Moderately slow permeability; moderately alkaline.	Soil features favorable.	Moderate shrink-swell potential.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil limitations for sewage disposal by—	
	Topsoil	Sand and gravel	Road fill [1]	Septic tank filter fields	Sewage lagoons
Divide: DdA	Good to depth of 12 inches.	Fair at depths below 30 inches.	Good	Moderate: high water table part of the time.	Severe: rapid permeability in substratum.
Edgeley: EbA, EbB, EbC	Good to depth of 10 inches; fair to depth of 20 inches.	Unsuitable	Fair: moderate shrink-swell potential; bedrock at depth of 36 to 60 inches.	Severe: moderately slow permeability in substratum.	Moderate: bedrock at depth of 36 to 60 inches.
Embden: EmA, EmB, EmC, EnA	Good to depth of 16 inches.	Fair for sand	Good	Slight	Severe: moderately rapid permeability.
*Fairdale: Fa, FaB, Fd, Fe (For LaPrairie part of Fe, see LaPrairie series.)	Good to depth of 8 inches.	Unsuitable	Fair: low to moderate shrink-swell potential.	Severe: subject to frequent flooding.	Severe: subject to frequent flooding.
*Fargo: FfA, Fg, FhA, FhB (For Hegne part of FhA and FhB, see Hegne series.)	Fair to depth of 16 inches.	Unsuitable	Poor: high shrink-swell potential; low shear strength.	Severe: slow permeability; surface ponding.	Slight
Fossum (Mapped only in a complex with Arveson soils.)	Good to depth of 15 inches.	Poor for sand; unsuitable for gravel.	Good	Severe: high water table.	Severe: moderately rapid permeability in substratum.
Gardena: GaA, GaB	Good to depth of 30 inches.	Unsuitable	Fair: frost hazard.	Moderate: moderate permeability.	Moderate: poor stability as fill material; moderate permeability.
Gilby:					
Gb, Gh	Good to depth of 12 inches.	Unsuitable	Poor: moderate shrink-swell potential; low shear strength.	Severe: moderately slow permeability in substratum.	Slight
Ge	Fair to depth of 8 inches.	Unsuitable	Poor: moderate shrink-swell potential; low shear strength.	Severe: high water table.	Slight

See footnote at end of table.

interpretations of the soils—Continued

Soil features affecting—							
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankments, dikes and levees	Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
Seasonal high water table.	Rapid permeability in substratum.	High compacted permeability.	High water table.	Low available water capacity; rapid permeability in substratum; may need drainage.	Not applicable.	Seasonal high water table.
Bedrock at depth of 36 to 60 inches.	Soil features favorable.	Bedrock at depth of 36 to 60 inches; fair to good stability.	Not applicable.	Moderately slow permeability; slope.	Soil features favorable.	Soil features favorable.
Subject to erosion.	Moderately rapid permeability.	High compacted permeability; susceptible to piping.	Not applicable.	Soil features favorable.	Soil features favorable.	Soil features favorable.
Subject to flooding.	Soil features favorable.	Fair stability; susceptible to piping.	Not applicable.	Subject to flooding.	Not applicable.	Subject to flooding.
High plasticity; subject to flooding.	Soil features favorable.	Impervious where compacted; high shrink-swell potential; susceptible to cracking.	Outlets difficult to obtain.	Slow permeability.	Not applicable.	Low shear strength; high shrink-swell potential.
Seasonal high water table.	Moderately rapid permeability in substratum.	High compacted permeability; susceptible to piping.	High water table.	High water table; poorly drained.	Not applicable.	High water table.
Frost heave.	Moderate permeability.	Poor stability; susceptible to piping.	Soil features favorable.	Soil features favorable.	Not applicable.	Soil features favorable.
Frost heave; unstable as embankment material.	Soil features favorable.	Fair to good stability; moderate shrink-swell potential.	Suitable outlets not available.	Moderately slow permeability; needs drainage.	Soil features favorable.	Moderate shrink-swell potential; high water table.
Boulders.	Soil features favorable.	Fair to good stability; moderate shrink-swell potential.	Suitable outlets not available.	Moderately slow permeability; stones.	Not applicable.	High water table.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil limitations for sewage disposal by—	
	Topsoil	Sand and gravel	Road fill [1]	Septic tank filter fields	Sewage lagoons
Glyndon: GlA, GlB, Gm	Good to depth of 9 inches; fair to depth of 16 inches.	Unsuitable	Fair: frost hazard.	Moderate: seasonal high water table.	Moderate: poor stability as fill material; moderate permeability.
*Grano: Gr, Gs (For Hegne part of Gs, see Hegne series.)	Fair to depth of 7 inches.	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: slow permeability in substratum.	Slight
*Hamar: Ha, Hd (For Ulen part of these units, see Ulen series.)	Fair to good to depth of 16 inches.	Fair for sand; unsuitable for gravel.	Good	Moderate to severe: high water table; surface ponding in places.	Severe: moderately rapid permeability.
*Hamerly: He, HgA, HgB (For Cresbard part of He, see Cresbard series. For Svea part of HgA, HgB, see Svea series.)	Variable to depth of 7 inches; good to depth of 16 inches.	Unsuitable	Poor: moderate shrink-swell potential; frost hazard.	Severe: slow permeability in substratum.	Slight
Hattie: Hh	Poor to depth of 5 inches.	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: steep slopes; subject to flooding; slow permeability in substratum.	Severe: steep slopes.
Hecla: HlA, HlB	Poor to depth of 15 inches.	Fair to good for sand; unsuitable for gravel.	Good	Slight	Severe: moderately rapid permeability.
*Hegne: HmA, HmB, Hn, Hs (For Fargo part of HmA, and HmB, see Fargo series.)	Fair to depth of 14 inches in HmA and HmB; poor to depth of 10 inches in Hn and Hs.	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: slow permeability.	Slight
Kloten: Kn	Fair to depth of 5 inches.	Unsuitable	Poor: shallow to bedrock.	Severe: steep slopes; slow permeability in shale rock.	Severe: shallow to bedrock; topography.
Lamoure: La	Fair to depth of 10 inches.	Unsuitable	Poor: moderate shrink-swell potential; low shear strength.	Severe: high water table.	Severe: subject to flooding.

See footnote at end of table

interpretations of the soils—Continued

Soil features affecting—							
Highway location	Farm ponds		Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
	Reservoir area	Embankments, dikes and levees				
Frost heave	Moderate permeability.	Poor stability; susceptible to piping.	Soil features favorable.	May need drainage.	Not applicable	Seasonal high water table.
Subject to flooding; high plasticity.	Soil features favorable.	Low shear strength; high shrink-swell potential; susceptible to cracking.	Outlets difficult to obtain.	Slow permeability; poorly drained; high water table.	Not applicable	Low shear strength; high shrink-swell potential.
Erodible where bare; high water table.	Moderately rapid permeability.	Moderately rapid permeability; susceptible to piping.	Soil features favorable.	Fair available water capacity; poorly drained; high water table.	Not applicable	High water table.
Frost heave	Soil features favorable.	Fair to good stability; moderate shrink-swell potential.	Soil features favorable.	Slow permeability; slope.	Soil features favorable.	Moderate shrink-swell potential.
Steep slopes	Soil features favorable.	Low shear strength; high shrink-swell potential; susceptible to cracking.	Not applicable	Slow permeability; slope.	Subject to erosion.	High shrink-swell potential. low shear strength.
Erodible	Moderately rapid permeability.	Moderately rapid permeability; susceptible to piping.	Not applicable	Fair available water capacity; susceptible to soil blowing; topography.	Not applicable	Soil features favorable.
High plasticity; subject to flooding.	Soil features favorable.	Low shear strength; high shrink-swell potential; susceptible to cracking.	Outlets difficult to obtain.	Slow permeability; salinity.	Not applicable	High shrink-swell potential; low shear strength.
Shallow to bedrock; unstable in cut slopes; topography.	Shallow to bedrock.	Shallow; limited volume of material.	Not applicable	Shallow to bedrock; steep slopes; low available water capacity.	Erodible; vegetation difficult to establish; shallow to bedrock.	Shallow to bedrock.
Subject to flooding.	Soil features favorable.	Fair stability; moderate shrink-swell potential.	Subject to flooding.	Moderately slow permeability; salinity; high water table; subject to flooding.	Not applicable	Subject to flooding; high water table.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil limitations for sewage disposal by—	
	Topsoil	Sand and gravel	Road fill [1]	Septic tank filter fields	Sewage lagoons
*Lankin: LeA, Lk, LnA, LnB (For Svea part of LnA, and LnB, see Svea series.)	Good to depth of 16 inches.	Unsuitable	Poor: moderate shrink-swell potential; frost hazard.	Severe: moderately slow permeability in substratum.	Slight: moderately slow permeability.
LaPrairie: Lp, Lr	Good to depth of 60 inches.	Unsuitable	Poor: moderate to high shrink-swell potential.	Moderate: flooded part of the time.	Severe: subject to flooding.
*Ludden: Lu, Ly (For Ryan part of Ly, see Ryan series.)	Poor	Unsuitable	Poor: low shear strength; high shrink-swell potential; frost hazard.	Severe: poorly drained; moderately slow permeability.	Severe: subject to flooding.
Maddock: Mk3 (For Hecla part of this unit, see Hecla series.)	Poor	Fair to good for sand; unsuitable for gravel.	Good	Slight	Severe: moderately rapid permeability.
Manfred: Mn	Poor	Unsuitable	Poor: moderate shrink-swell potential; moderate shear strength.	Severe: very poorly drained; slow permeability.	Slight
Ojata: Oa	Unsuitable	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: slow permeability.	Moderate: fair to poor stability as embankment material.
Overly: OeA, OlA, OlB, OlC, Om, OvA, Ow.	Good to depth of 17 inches.	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: moderately slow permeability.	Moderate: fair stability as fill material.
*Parnell: Pa, Pt (For Tonka part of Pt, see Tonka series.)	Good to depth of 18 inches.	Unsuitable	Poor: high shrink-swell potential; low shear strength; high water table.	Severe: slow permeability; poorly drained.	Slight
Perella: Pu	Good to depth of 15 inches.	Unsuitable	Poor: high shrink-swell potential; low shear strength; high water table.	Severe: moderately slow to slow permeability in substratum.	Moderate: fair to poor stability as fill material.

See footnote at end of table.

interpretation of the soils—Continued

Soil features affecting—						
Highway location	Farm ponds		Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
	Reservoir area	Embankments, dikes and levees				
Stones and boulders; frost heave.	Soil features favorable.	Fair to good stability; moderate shrink-swell potential.	Soil features favorable.	Moderately slow permeability; slope in some areas.	Soil features favorable.	Moderate shrink-swell potential.
Subject to flooding.	Soil features favorable.	Fair to good stability; moderate to high shrink-swell potential.	Not applicable	Moderate to moderately slow permeability; subject to flooding.	Not applicable	Subject to flooding.
Subject to flooding.	Soil features favorable.	Low shear strength; high shrink-swell potential; susceptible to cracking.	High water table; level to nearly level; salts.	Moderately slow permeability; poorly drained; salinity.	Not applicable	Subject to flooding; low shear strength; high shrink-swell potential.
Erodible	Moderately rapid permeability.	High compacted permeability; susceptible to piping.	Not applicable	Low available water capacity; susceptible to soil blowing.	Not applicable	Soil features favorable.
Ponded water	Soil features favorable.	Fair stability; moderate shrink-swell potential; subject to dispersion.	Outlets not available.	Slow permeability; moderately to strongly alkaline; poorly drained.	Not applicable	High water table; moderate shrink-swell potential.
High water table; frost heave.	Soil features favorable.	Fair to poor stability; high shrink-swell potential; susceptible to piping.	Outlets difficult to obtain.	Strongly saline; poorly drained.	Not applicable	Low shear strength; high shrink-swell potential; high water table.
Plasticity; frost heave.	Soil features favorable.	Fair stability; high shrink-swell potential.	Outlets difficult to obtain.	Moderately slow permeability.	Not applicable	High shrink-swell potential.
Organic material; ponded water.	Soil features favorable.	Poor to fair stability; high shrink-swell potential.	Not applicable	Slow permeability; poorly drained.	Not applicable	High water table.
Seasonal ponded water.	Soil features favorable.	Poor to fair stability; low shear strength; high shrink-swell potential.	Outlets limited	Moderately slow to slow permeability; poorly drained.	Not applicable	High water table.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of—			Soil limitations for sewage disposal by—	
	Topsoil	Sand and gravel	Road fill [1]	Septic tank filter fields	Sewage lagoons
Rauville: Ra	Unsuitable	Unsuitable	Poor: high water table; low shear strength.	Severe: high water table.	Severe: rapid permeability.
Renshaw: ReA, ReB	Good to depth of 15 inches.	Good	Very good	Slight: danger of pollution.	Severe: rapid permeability in substratum.
Rockwell: Ro	Good to depth of 6 inches; fair to depth of 14 inches.	Unsuitable	Fair: moderate shrink-swell potential; low shear strength.	Severe: moderately slow permeability in substratum; high water table part of the time.	Slight for material below depth of 26 inches
Ryan (Mapped only in an undifferentiated unit with Ludden soils.)	Poor: high content of clay.	Unsuitable	Poor: low shear strength; high shrink-swell potential; salts.	Severe: poorly drained; slow permeability.	Severe: subject to flooding.
*Sioux: Sr, SsE (For Renshaw part of these units, see Renshaw series.)	Unsuitable	Fair for sand; good for gravel.	Good	Slight: danger of pollution.	Severe: rapid permeability.
*Svea: SuA, SvA (For Barnes part of SuA, see Barnes series. For Cresbard part of SvA, see Cresbard series.)	Good to depth of 19 inches.	Unsuitable: fair as a source of stone for riprap.	Fair: moderate shrink-swell potential; moderate shear strength.	Severe: moderately slow permeability in substratum.	Slight
Tonka (Mapped only in an undifferentiated unit with Parnell soils.)	Good to depth of 16 inches.	Unsuitable	Poor: high shrink-swell potential; moderate shear strength.	Severe: poorly drained; slow permeability.	Slight
Towner: ToA	Good to depth of 13 inches.	Poor for sand; unsuitable for gravel.	Fair: moderate shrink-swell potential in substratum.	Severe: moderately slow permeability in substratum.	Slight for material below depth of 31 inches.
Ulen: Un	Fair to good to depth of 16 inches.	Fair for sand; unsuitable for gravel.	Very good	Moderate: seasonal high water table.	Severe: moderately rapid permeability in substratum.

See footnote at end of table.

interpretations of the soils—Continued

Soil features affecting—						
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankments, dikes and levees	Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
Ponded water; high water table.	Rapid permeability in substratum.	High compacted permeability; susceptible to piping.	Outlets limited; erodibility of channels.	High water table; poorly drained.	Not applicable	High water table.
Soil features favorable.	Rapid permeability in substratum.	High compacted permeability.	Not applicable	Low available water capacity; shallow over gravel.	Shallow to sand and gravel.	Soil features favorable.
Frost heave; seasonal high water table.	Moderately rapid permeability in upper layers.	Susceptible to piping to depth of 26 inches; fair to good stability; moderate shrink-swell potential below depth of 26 inches.	Outlets difficult to obtain.	Moderately slow permeability in substratum; high water table.	Not applicable	Moderate shrink-swell potential in substratum; seasonal high water table.
Subject to flooding; high plasticity.	Soil features favorable.	Low shear strength; high shrink-swell potential; high dispersion; subject to cracking.	High water table; accumulations of salt; level.	Strongly alkaline; slow permeability.	Not applicable	Subject to flooding; low shear strength; high shrink-swell potential
Soil features favorable.	Rapid permeability in substratum.	High compacted permeability.	Not applicable	Shallow to sand and gravel; low available water capacity.	Not applicable	Soil features favorable.
Frost heave	Soil features favorable.	Fair to good stability; moderate shrink-swell potential.	Not applicable	Moderately slow permeability.	Soil features favorable.	Moderate shrink-swell potential.
Ponded water	Soil features favorable.	Fair to good stability; high shrink-swell potential.	Not applicable	Slow permeability; poorly drained.	Not applicable	High water table; high shrink-swell potential.
Erodible surface material.	Moderately rapid permeability in upper layers.	Susceptible to piping in upper 31 inches; fair to good stability and moderate shrink-swell potential below depth of 31 inches.	Not applicable	Moderately slow permeability in substratum; susceptible to soil blowing.	Erodible	Moderate shrink-swell potential in substratum.
Erodible where bare.	Moderately rapid permeability in substratum.	High compacted permeability; susceptible to piping.	Stability of banks.	Fair available water capacity; susceptible to soil blowing; may need drainage.	Not applicable	Soil features favorable.

TABLE 7.—*Engineering*

Soil series and map symbols	Suitability as a source of— Topsoil	Sand and gravel	Road fill [1]	Soil limitations for sewage disposal by— Septic tank filter fields	Sewage lagoons
*Vallers: Va, Vh, Vm (For Hamerly part of Vh and Vm, see Hamerly series.)	Fair to depth of 18 inches.	Unsuitable	Poor: high shrink-swell potential; low shear strength.	Severe: moderately slow to slow permeability in substratum; high water table.	Slight
*Vang: VnA (For Brantford part of this unit; see Brantford series.)	Good to depth of 10 inches; fair to depth of 18 inches.	Poor: high content of shale.	Good	Slight: danger of pollution.	Severe: moderately rapid permeability.
Wahpeton: Wa	Good to depth of 18 inches; fair to depth of 60 inches.	Unsuitable	Poor: low shear strength; high shrink-swell potential.	Severe: subject to flooding; moderately slow permeability.	Moderate: subject to flooding; unstable as fill material.
Walsh: WhC, WlA, WlB, Wm, WnA	Good to depth of 22 inches.	Unsuitable	Moderate: moderate shrink-swell potential.	Severe: moderately slow permeability in substratum.	Moderate: moderate and moderately slow permeability.
Waukon: WoB, WoD	Good to depth of 13 inches; fair to depth of 24 inches.	Unsuitable	Fair: moderate shrink-swell potential.	Severe: moderately slow permeability.	Slight: slope
*Zell: ZgC, ZgE (For Gardena part of these units, see Gardena series.)	Poor	Unsuitable	Poor: high shrink-swell potential; low shear strength.	Severe: topography in some places; steep slopes.	Severe: steep slopes.

[1] Rated according to AASHO classification.

interpretations of the soils—Continued

Soil features affecting—						
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankments, dikes and levees	Agricultural drainage	Irrigation	Grassed waterways	Foundations for low buildings
High water table; stony; many shallow depressions.	Soil features favorable.	Fair to good stability; high shrink-swell potential.	Suitable outlets lacking.	Slow permeability; poorly drained.	Not applicable	High water table; high shrink-swell potential.
Soil features favorable.	Moderately rapid permeability in substratum.	High compacted permeability; susceptible to piping.	Not applicable	Soil features favorable.	Moderately deep to sand and gravel.	Soil features favorable.
Subject to flooding and sliding.	Soil features favorable.	Low shear strength; high shrink-swell potential; subject to cracking.	Not applicable	Moderately slow permeability in substratum; subject to flooding.	Not applicable	High shrink-swell potential; low shear strength; subject to flooding.
Soil features favorable.	Soil features favorable except where sand and gravel are in substratum.	Fair to good stability; moderate shrink-swell potential; susceptible to piping.	Not applicable	Slope; moderate and moderately slow permeability.	Soil features favorable.	Moderate shrink-swell potential.
Topography	Soil features favorable.	Fair to good stability; moderate shrink-swell potential.	Not applicable	Moderately slow permeability; slope and topography.	Soil features favorable.	Moderate shrink-swell potential.
Steep slopes; fair stability of slopes.	Soil features favorable.	Fair stability; high shrink-swell potential.	Not applicable	Steep slopes; topography; moderately slow or slow permeability.	Soil features favorable.	High shrink-swell potential in substratum.

TABLE 8.—*Sand and gravel borrow pits in Walsh County*

Location	Estimated quantity available	Quality	Percentage retained on sieve—		Plasticity index	Suitable for—
			¼-inch	No. 4		
	Cubic yard					
NE¼ sec. 36, T. 155 N., R. 54 W.[1]	15, 212	Good	26	31	0	Seal aggregate; traffic surfacing.
NW¼ sec. 36, T. 155 N., R. 54 W.	110, 000	Good	28	33	0	Combined aggregate.
SE¼ sec. 23, T. 155 N., R. 55 W.	96, 000	Good	23	28	0	Combined aggregate; traffic surfacing.
SW¼ sec. 23, T. 155 N., R. 55 W.	55, 000	Fair	14	18	4. 0	Traffic surfacing.
NW¼ sec. 27, T. 155 N., R. 56 W.[1]	50, 320	Excellent	39	44	0	Concrete aggregate if washed.
NW¼ sec. 11, T. 156 N., R. 49 W.	127, 777	Fair	11	15	3. 0	Gravel subbase. Material is 18 percent shale.
NW¼ sec. 21, T. 156 N., R. 56 W.[1]	257, 777	Good	46	42	0	Concrete aggregate if washed. Material is 3.4 percent clay and colloids.
NW¼ sec. 26, T. 156 N., R. 56 W.	85, 000	Good	36	40	0	Combined aggregate; traffic surfacing. Material is 7 percent shale.
SW¼ sec. 18, T. 156 N., R. 55 W.	20, 000	Fair	28	32	3. 1	Traffic surfacing.
NE¼ sec. 33, T. 156 N., R. 55 W.	29, 000	Fair	19	23	(2)	Traffic surfacing.
SW¼ sec. 34, T. 156 N., R. 55 W.	9, 000	Fair	23	27	(2)	Traffic surfacing.
SW¼ sec. 20, T. 157 N., R. 54 W.	77, 716	Unknown	(2)	(2)	(2)	Sand.
NW¼ sec. 22, T. 157 N., R. 55 W.	19, 403	Good	36	42	0	Combined aggregate. Material is 3.4 percent clay and colloids.
SW¼ sec. 28, T. 158 N., R. 56 W.	21, 000	Fair	33	37	(2)	Traffic surfacing; pit-run base. Material is 9 percent shale.
Sec. 29, T. 158 N., R. 56 W.	(3)	Good	33	38	0 to 3.5	Bituminous treated base; combined aggregate. Material is 8 percent clay and colloid; 9 percent shale.
NW¼ sec. 4, T. 158 N., R. 56 W.	(3)	Good	23	28	(2)	Gravel surfacing. Material is 8 percent shale.
SW¼ sec. 5, T. 158 N., R. 55 W.[1]	24, 500	Fair	39	43	6. 0	Traffic surfacing. Material is 10 percent shale.

[1] Pit is owned or leased by State.
[2] Value not determined.
[3] Unknown but believed to be substantial.

Engineering classification systems

Agricultural scientists of the U.S. Department of Agriculture classify soils according to texture (*5*). In some ways this system of naming textural classes is comparable to the systems most commonly used by engineers for classifying soils; that is, the system of the American Association of State Highway Officials (AASHO) and the Unified system.

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (*1*). In this system soil materials are classified in seven principal groups. The groups range from A–1 (gravelly soils having high bearing capacity, the best soils for subgrade) to A–7 (clayey soils having low strength when wet, the poorest soils for subgrade). Within each group the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest. The group index number of the tested soils is shown in parentheses following the soil group symbol in table 5.

The Unified Soil Classification System developed by the U.S. Army Corps of Engineers (*9*) is based on texture, plasticity, liquid limit, and performance as engineering construction material. In this system, soil materials are identified as coarse grained (eight classes), fine grained (six classes), or highly organic (one class). The coarse-grained soils (less than half the material, by weight, passes the No. 200 sieve) are identified by the following symbols: GC, GW, GP, GM, SW, SP, SM, and SC. The fine-grained soils (more than half the material, by weight, passes the No. 200 sieve) are identified by the following symbols: ML, CL, OL, MH, CH, and OH. The last column in table 5 gives the classification of the tested soils according to the Unified system.

In this survey, clean gravel is identified by the symbols GW and GP, and gravel mixed with nonplastic fine material, by the symbol GM. Clean sand mixed with nonplastic silt is identified by the symbol SW; sand mixed with plastic silt, by SM. Soils containing a high percentage of low-plasticity clay are identified by the symbol CL; those containing high plasticity clay, by CH.

Engineering test data

To help evaluate the soils in Walsh County for engineering purposes, samples from several soil profiles were tested according to standard procedures. The soils were selected for testing because of their contrasting morphology, their extent in the county, and the lack of engineering data on them in this and in adjoining counties. The results of these tests are given in table 5.

Moisture-density data are obtained by compacting soil material at a successively higher moisture content. Assuming that the compactive effort remains constant, the density of the compacted material increases until the optimum moisture content is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed "maximum dry density." Moisture-density data are important in earthwork because, as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content. In engineering work soil material is compacted to increase shear strength and to decrease permeability and the risk of future settling.

The tests to determine liquid limit and plastic limit measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic. As the moisture content is further increased, the material changes from a plastic to a liquid. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic. The liquid limit is the moisture content at which the soil material passes from a plastic to a liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range in moisture content within which a soil material is in a plastic condition.

Estimated engineering properties

Table 6 shows estimates of soil properties that affect engineering significantly. Depth to bedrock is not shown, because most soils in the county are deep enough that bedrock does not affect their use. In the Kloten soils, however, shale bedrock is at a depth of only 13 to 20 inches, and in the Edgeley soils, it is at a depth of 24 to 60 inches. In most of the other soils, it is at a depth of more than 60 inches.

Depth to a seasonal high water table is shown as a range if the water table is less than 5 feet below the surface during wet seasons. It is shown as 5+ if the water table is consistently at a depth of more than 5 feet. The water table is generally nearest the surface in spring. It rises rapidly after the soils have thawed, and it then recedes for the rest of the year, except for minor fluctuations after heavy rains.

Permeability indicates the rate at which water moves through undisturbed soil material. The estimates are based on structure and porosity of the soils and on the results of permeability and infiltration tests using a ½-inch head of pressure on soil that is slightly below moisture saturation.

Available water capacity refers to the amount of water held in a form that plants can use readily. The figures in the table show the amount of water that will wet air-dry soil material to a depth of 1 inch without deeper percolation.

Reaction (pH) refers to the degree of acidity or alkalinity of a soil. The degrees of acidity or alkalinity are defined under the heading "Reaction" in the Glossary. The reaction of a soil can be used to predict corrosivity of the soil to some metals. Cast iron and aluminum, for example, have been commonly found to corrode in soils that have a pH higher than 8.0.

Salinity is described in terms of salinity classes. These classes are based on the electrical conductivity of saturated soil extract, expressed in millimhos per centimeter, at a temperature of 25° Centigrade. The following salinity classes are used in this survey:

Salinity class	*Conductivity of soil extract in millimhos per centimeter*
None	2
Slight	2 to 4
Moderate	4 to 8
Severe	8 to 16
Very severe	16

Dispersion is a term used to describe how readily soil aggregates slake down in water and go into suspension. A rating of *high* means that the soil aggregates break down, or slake, easily. A rating of *low* means the soil aggregates resist dispersion.

Shrink-swell potential indicates the volume change to be expected in soil when the moisture content changes. It is based on the liquid limit and the plasticity index of the soil. A rating of *high* is generally related to the content of clay and is characteristic of soils classified as A–7 or CH.

Engineering interpretations

Table 7 shows, for each soil series, suitability of the soils as a source of topsoil, sand and gravel, and material for road construction. It also shows the degree and kind of limitations for use for sewage disposal systems, and the soil features that affect the location of highways, foundations of buildings, irrigation, and the construction and maintenance of stated engineering works. The information in this table is based on test data, on descriptions of soils in other parts of this survey, and on experience with these and similar soils in adjoining counties.

Topsoil refers to soil material used to grow vegetation. Normally, only the surface layer of a soil is rated for topsoil. Suitability for topsoil depends mainly on texture and depth of the available material, which must be capable of being worked into a good seedbed for seeding or sodding, yet able to resist erosion on steep slopes. The soils having a large amount of sand, silt, or clay are generally given a rating of poor or fair. Silty clays, loamy sands, and sandy loams are given ratings ranging from fair to good.

Road fill is the material used to support the subbase and base course or surface course of a road. Suitability ratings for road fill depend mainly on texture and water content of the soil material. In general, sandy material containing adequate binder is the best because it is least affected by adverse weather and can be worked during a greater number of months of the year. Silt and fine sand are rated fair to poor because they are erodible, are difficult to compact, and require moderately gentle slopes and rapid establishment of vegetation for control of erosion. Clay and organic material are poorest because they are highly plastic and contain a large amount of water. Soil material rated A–4 to A–7 in the AASHO classification is rated very poor to fair as road fill, and very poor as material for subgrade. Sand, fine gravel, and other coarse soil material rated A–3 to A–1 are best for road fill and subgrade. Where A–4 and A–7 materials are used as subgrade, insulation courses com-

posed of A-1 and A-2 material are generally required under a thin, flexible pavement.

The severity of limitations where a soil is intended for use for a sewage disposal system is based on the stability and permeability of the soil and on the height of the water table.

Features that affect the use of a soil for the location of a highway, for the foundations of a building, or for irrigation and other engineering works are shown in the remaining columns of table 7. Information given in these columns concerns features that are unfavorable for the construction, operation, or maintenance of the stated structure or that are unfavorable for the stated practice.

Sand and gravel resources

Sand and gravel are among the most abundant and valuable minerals in Walsh County. The location, quantity, and quality of the known deposits are shown in table 8. Most deposits of sand and gravel are on eskers and beach lines, which pinch out in some places and recur again within a short distance. As a rule, the sand and gravel in this county have a high content of shale, clay, and soft rock. They require washing and screening to improve their suitability for use as concrete aggregate. Material from some pits has been used as base course for road pavement. That from other pits has been used as aggregate for light-duty bituminous paving.

Formation and Classification of Soils

This section consists of two main parts. The first part tells how the factors of soil formation have affected the development of soils in Walsh County. The second explains the system of soil classification currently used in the United States and places each soil series in the main classes of that system.

Factors of Soil Formation

Soils are natural bodies covering the surface of Walsh County. They have formed through natural processes acting on material deposited by glacial agencies. The characteristics of a soil at any given point are determined by (1) the kind of parent material, (2) the climate under which the soil material has accumulated and has existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the processes of soil formation have acted on the soil material. The factors of soil formation are so interrelated in their effects on the development of soils that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four.

Parent material

Most of the soils of this county have formed in parent material of glacial origin. This material consists of glacial till that was deposited by glacial ice, of glacial lake sediment that has accumulated in still water, and of glacial outwash that was deposited by moving water. Other soils have formed in alluvium deposited by the waters of streams, or in local alluvium of recent origin.

Climate

Because of its influence in determining the kind of natural vegetation, and its influence in weathering of the parent material, climate is a dominant factor in the formation of soils. The climate of this county has favored the accumulation of organic matter and lime in the soils. As a result, most of the soils have high natural fertility and desirable physical properties. In many soils a receding seasonal high water table has left lime in the soils in a zone that begins within 16 inches of the soil surface. Other soils in the county have a zone of lime accumulation beginning below a depth of 16 inches.

Plant and animal life

Like climate, living matter on and in the soil is an active factor in the formation of soils. Plants have had a greater influence on the formation of soils than have animals, for their roots extend into the accumulated parent material and slowly change it to a natural body that has genetically related horizons. The native vegetation of this county was predominantly tall and medium-tall prairie grasses. In addition to these grasses, microscopic plants and animals living in the soil caused the residue of larger plants and animals to decay to primary minerals. The micro-organisms stored part of the products of decay in their bodies during their lifetime. When they died, the accumulation of organic matter was returned to the soils. Insects, worms, and larger animals have mixed soil material by burrowing, have moved plant material from the soil surface to the lower layers, and have transformed the organic matter in the native vegetation to simpler forms.

Relief

The effects oft he other soil-forming factors are conditioned by the relief of the landscape. In areas of high local relief, some soils have a thin surface layer because of rapid runoff and geologic erosion. In areas of low local relief, most soils have a thick surface layer, and colors that indicate that drainage is moderately good to very poor.

Time

Time is needed for changing parent material into a soil profile. For most soils a very long time is needed for the development of distinct soil horizons. Most of the soils of this county are mature, and they reflect development of a soil profile in material that has been in place for a long time. The soils of the flood plains of streams, where floodwaters periodically deposit fresh sediment, are generally immature. In those areas the soil material has not been in place long enough for distinct horizons to have developed.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics; assemble knowledge about them; see their relationships to one another and to the whole environment; and develop principles that help us understand their behavior and response to manipulation. First through classification, and then through the use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The current system of classification defines classes in terms of observable or measurable properties of soils. The

properties chosen are primarily those that permit grouping soils that are similar in genesis. Genesis, or mode of soil origin, does not appear in the definitions of the classes; it lies behind the classes. The classification is designed to accommodate all soils. It employs a unique nomenclature that is both connotative and distinctive.

The classification has six categories. Beginning with the most inclusive, the categories are the order, suborder, great group, subgroup, family, and series. This system of classification was adopted for general use by the National Cooperative Soil Survey, effective January 1, 1965. Readers interested in developments of the current system should search the latest literature available (*3*, *6*). Table 9 places the soil series of Walsh County in some categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

TABLE 9—*Soil series classified according to the current system*

Series	Family	Subgroup	Order
Antler	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Arveson	Coarse-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Arvilla	Sandy, mixed	Udic Haploborolls	Mollisols.
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Bearden	Fine-silty, mixed, frigid	Aeric Calciaquolls	Mollisols.
Benoit	Fine-loamy over sandy or sandy-skeletal, mixed, frigid.	Typic Calciaquolls	Mollisols.
Borup	Coarse-silty, mixed, frigid	Typic Calciaquolls	Mollisols.
Brantford	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls (less than 20 inches to shale gravel).	Mollisols.
Buse	Fine-loamy, mixed	Udorthentic Haploborolls	Mollisols.
Cashel	Fine, montmorillonitic	Fluventic Haploborolls	Mollisols.
Cavour	Fine, mixed	Udic Natriborolls	Mollisols.
Coe	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Colvin	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols.
Cresbard	Fine, mixed	Glossic Udic Natriborolls	Mollisols.
Divide	Fine-loamy over sandy or sandy-skeletal, mixed, frigid.	Aeric Calciaquolls	Mollisols.
Edgeley	Fine-loamy, mixed	Udic Haploborolls	Mollisols.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Fairdale	Fine-loamy, mixed	Aquic Fluventic Haploborolls	Mollisols.
Fargo	Fine, montmorillonitic, noncalcareous, frigid	Vertic Haplaquolls	Mollisols.
Fossum	Sandy, mixed, calcareous, frigid	Typic Haplaquolls	Mollisols.
Gardena	Coarse-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Gilby	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Glyndon	Coarse-silty, mixed, frigid	Aeric Calciaquolls	Mollisols.
Grano	Fine, montmorillonitic, calcareous, frigid	Vertic Haplaquolls	Mollisols.
Hamar	Sandy, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Hamerly	Fine-loamy, mixed, frigid	Aeric Calciaquolls	Mollisols.
Hattie	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Hecla	Sandy, mixed	Pachic Udic Haploborolls	Mollisols.
Hegne	Fine, montmorillonitic, frigid	Typic Calciaquolls	Mollisols.
Kloten	Loamy, mixed	Lithic Haploborolls (10 to 20 inches to bedded shale).	Mollisols.
Lamoure	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols.
Lankin	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
LaPrairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Mollisols.
Ludden	Fine, montmorillonitic, calcareous, frigid	Vertic Haplaquolls	Mollisols.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Manfred	Fine-loamy, mixed, calcareous, frigid	Typic Natraquolls [1]	Mollisols.
Ojata	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols.
Overly	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols.
Parnell	Fine-montmorillonitic, noncalcareous, frigid	Typic Argiaquolls	Mollisols.
Perella	Fine, silty, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols.
Rauville	Fine, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols.
Renshaw	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls (10 to 20 inches to gravel)	Mollisols.
Rockwell	Coarse-loamy over clayey, mixed, frigid	Typic Calciaquolls	Mollisols.
Ryan	Fine, montmorillonitic, calcareous, frigid	Typic Natraquolls	Mollisols.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols.
Svea	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Tonka	Fine, montmorillonitic, frigid	Argiaquic Argialbolls	Mollisols.
Towner	Sandy over loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Ulen	Coarse-loamy, mixed, frigid	Aeric Calciaquolls	Mollisols.
Vallers	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols.
Vang	Fine-loamy over sandy or sandy-skeletal, mixed	Udic Haploborolls [1] (20 to 40 inches to gravel)	Mollisols.
Wahpeton	Fine, montmorillonitic	Udertic Haploborolls	Mollisols.
Walsh	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols.
Waukon	Fine-loamy, mixed	Mollic Eutroboralfs [2]	Alfisols.
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols.

[1] Classification tentative.
[2] Part of the soil mapped as Waukon loam has a mollic epipedon, and part does not.

ORDER.—Ten soil orders are recognized in the current system. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different kinds of climate. The two soil orders in Walsh County (see table 9)) are Mollisols and Alfisols.

Mollisols have formed under grass and have a thick, dark-colored surface horizon containing colloids in which bivalent cations are dominant. The soil material in these soils has not been mixed by shrinking and swelling.

Alfisols are mineral soils that contain horizons of clay accumulation. Unlike the Mollisols, they lack a thick, dark-colored surface layer that contains colloids in which bivalent cations are dominant, but the base status of the lower horizons is not extremely low.

SUBORDERS.—Each order is divided into groups (suborders), primarily on the basis of characteristics that seem to produce classes that have the greatest genetic similarity. Suborders narrow the broad climatic range permitted in the orders. Soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from the climate or vegetation.

GREAT GROUPS.—Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and other features. The horizons used as a basis for distinguishing between great groups are those in which clay, iron, or humus has accumulated or those that contain a pan that interferes with the growth of roots or the movement of water. The features commonly used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium) and the like. The great group is not shown separately in table 9, because it is the last word in the name of the subgroup.

SUBGROUPS.—Great soil groups are subdivided into subgroups. One of these represents the central, or typic, segment of the group. Other subgroups have properties of the group but have one or more properties of another great group, suborder, or order, and these are called intergrades. Subgroups may also be established for soils having properties that intergrade outside the range of any other great group, subgroup, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

FAMILIES.—Families are separated within a subgroup, primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES.—Series are explained in the section "How This Survey Was Made" and in the Glossary.

General Nature of the County

This section briefly discusses the history of the county and gives facts about the physiography, relief, drainage, and climate. It also describes farming and watershed development in the county. Agricultural data are from records of the U.S. Bureau of the Census.

Claims for land along the Park River were filed as early as 1851, but the first white settlement in the area that is now Walsh County was on the site of Grafton in 1879. Thomas Cooper, who started the settlement and who later became the postmaster, named the place Grafton in honor of his wife's former home in Grafton, N.H. Walsh County was organized in 1881 from parts of Pembina and Grand Forks Counties, and Grafton was selected as the county seat. By 1883, the population of this town was about 2,000, and by 1960 the population had increased by 5,885. The population of Walsh County in 1960 was 17,997, about half of which lived on farms. The main industry in the county is supplying agricultural materials, but there is also some light manufacturing and some processing of agricultural products.

The county is served by two railroads. U.S. Highway No. 81, Interstate Highway I–29, and State Highways 17, 18, and 32 link many of the towns in Walsh County and other areas with Grafton. Municipal airports are located near Grafton, Park River, and Adams. These airports have facilities for servicing and storing light aircraft.

Physiography, Relief, and Drainage

Differences in geology and drainage have divided Walsh County into five distinctly different land areas (fig. 10). These areas are the lake plain, the area of beach lines and delta deposits, the Edinburg Moraine, the Golden Valley, and the rolling ground moraine.

The lake plain is a nearly level area that slopes slightly toward the northeast. The elevation along the Red River, which flows north, is about 800 feet, and that along the western boundary of the lake plain is about 900 feet. This plain is a part of the floor of former Lake Agassiz, which covered much of the county during the glacial period. It is covered by loamy and clayey sediment that was deposited on the floor of the lake. Surface drainage is somewhat poor because of the nearly level gradient and the microrelief of the slight depressions and the intervening low ridges. The dominant soils are the Bearden, Glyndon, and Hegne.

The area occupied by beach lines and delta deposits is a gently sloping plain marked by several beach lines that extend in a southeast-northwest direction. Elevations in this area range from about 900 feet along the east side, to 1,100 feet just west of the town of Park River. The beach lines were formed when Lake Agassiz receded from its highest level to succeeding lower levels (fig. 11). Deltas also formed along the western margin of the lake while the lake was forming and during its subsequent disappearance. Drainage in this area is mainly moderate to good, but it is poor in marshes associated with the beach lines. The dominant soils of this area are the Embden, Gilby, and Lankin.

The Edinburg Moraine consists of a range of hills that mark the farthest advance of the last glacier in the area that is now Walsh County. Elevation of the Edinburg Moraine is mainly between 1,100 and 1,250 feet, but it is as high as 1,290 feet in some hilly areas. Drainage in this area is generally good to excessive, but it is poor in the many depressions. The dominant soils in this area are the Barnes, Buse, and Parnell.

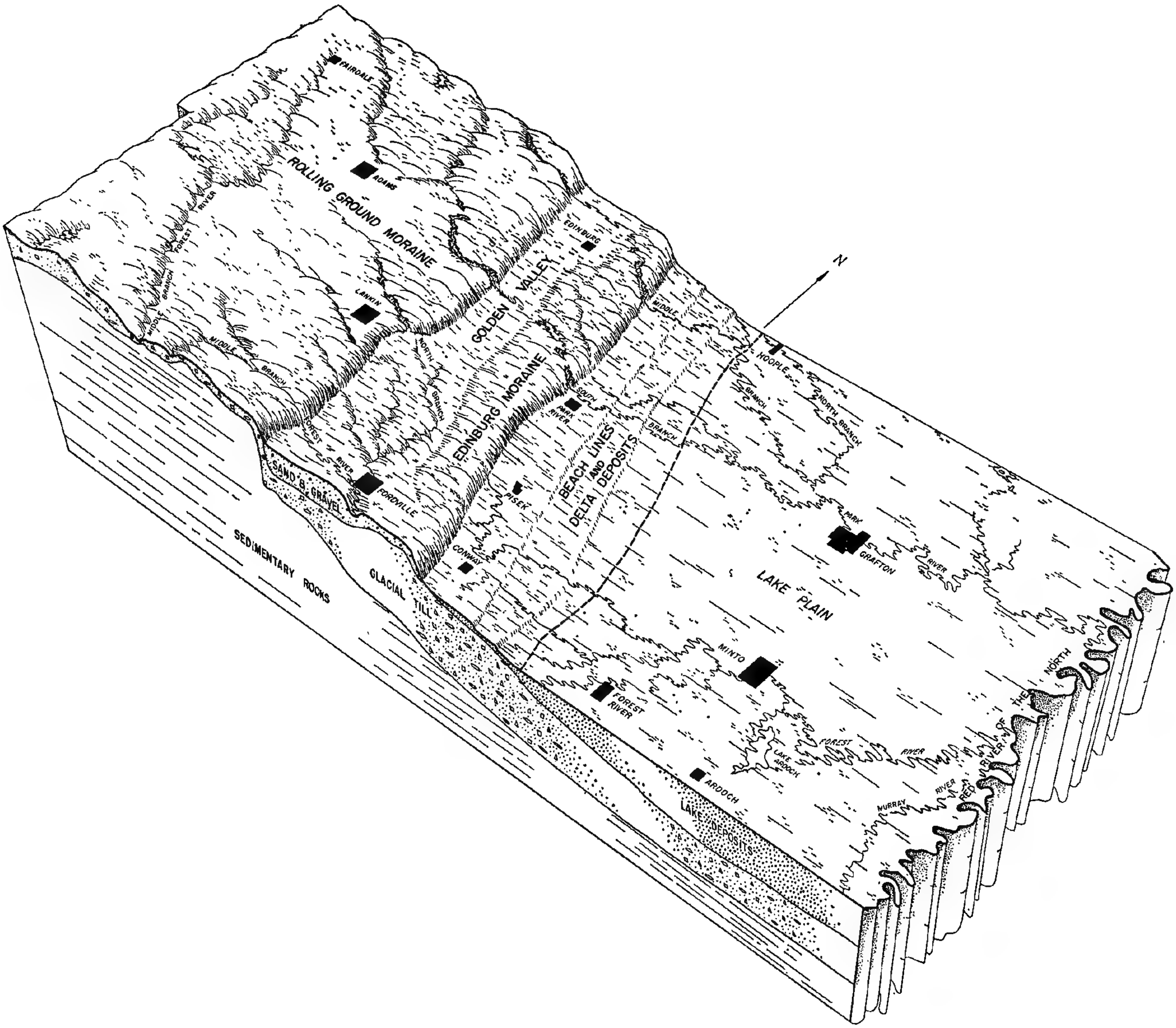

Figure 10.—**Physiographic features of Walsh County, N. Dak.**

Golden Valley is a nearly level plain that slopes gently to the south. Elevations range from about 1,130 feet near Fordville to about 1,250 feet west of Edinburg. Golden Valley was formerly the channel of a glacial river that emptied into Lake Agassiz. The southern one-third of this valley contains an extensive deposit of gravel. The northern two-thirds is composed of loamy and clayey material. Surface drainage is moderately good or good. The dominant soils of this area are the Walsh and Renshaw.

The rolling ground moraine is an area of glacial till plains that is mainly rolling but that includes some undulating areas. The till plains are dotted by many depressions in which the soils remain wet for long periods. The general slope of the moraine is toward the east and south. Elevations are about 1,250 feet along the eastern edge of the moraine, 1,540 feet in the southwestern part, and as much as 1,600 feet in the northwestern part. A point along the railroad right-of-way northwest of Fairdale has the highest elevation, 1,635 feet, of any place in the county. This ground moraine is drained mainly by the South Branch of the Park River and by the Middle and North Branches of the Forest River. The extreme western and southwestern parts, however, drain into the Devils Lake system. The dominant soils of this ground moraine are the Barnes, Svea, Hamerly, and Parnell.

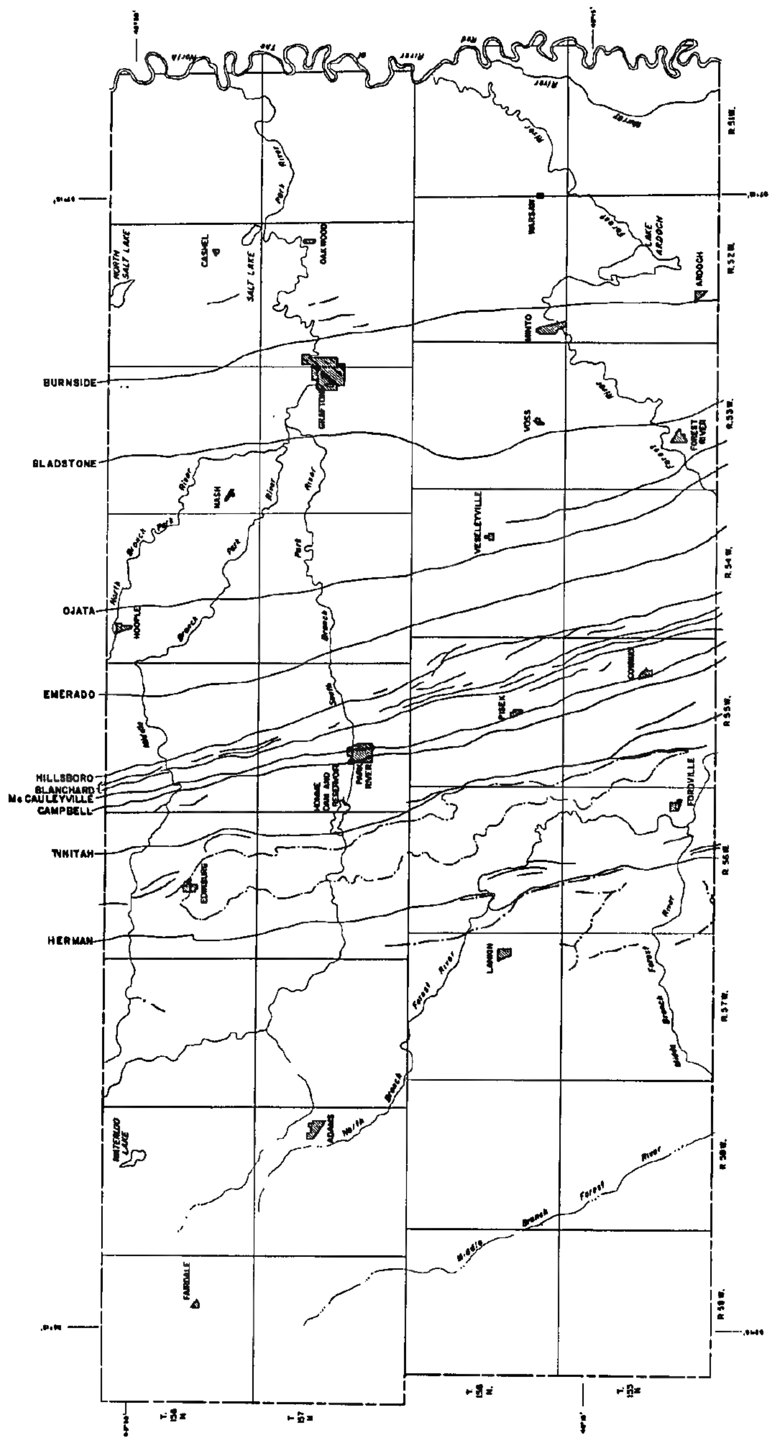

***Figure 11.*—Lake Agassiz beach lines and the principal streams in Walsh County.**

The present landscape of Walsh County was formed by the action of ice and water during the Late Wisconsin glacial period. Glaciers that descended from the north pushed earth material across the area that is now Walsh County. The Edinburg Moraine and the rolling ground moraine resulted from the movement of glaciers. Except that soils have formed on the surface, these moraines have not changed much since they were formed.

As the glacier melted, water accumulated along its southern edge, forming Lake Agassiz. At its greatest extent, this lake filled the basin now referred to as the Red River Valley, which extends through North Dakota, Minnesota, and South Dakota. The width of Lake Agassiz in what is now Walsh County was about 33 miles from east to west. The lake covered approximately 506,000 acres, or about 60 percent of the present county.

At the time Lake Agassiz was most extensive, it was at an elevation of about 1,275 feet. This is indicated by the location and elevation of the Herman Beach line, which lies west of Edinburg and Fordville. At this level, the lake would have had a depth of more than 450 feet at the present site of Grafton, and it would have had a depth of more than 250 feet at the present site of Park River. Except for several of the highest areas that were islands in Lake Agassiz, the Edinburg Moraine was totally submerged.

The most important beach line is the Campbell, which extends along the western edge of the Park River. The Burnside beach line, just east of Grafton, is the last one formed. The Burnside beach line has been breached in several places by postglacial surface runoff. It now consists of several ridges of silty and clayey material, 8 to 10 feet high and 1,250 to 3,500 feet long.

Climate [5]

Walsh County, near the geographical center of the continent of North America, has a continental climate. Winters are cold, and snow often covers the ground. Summer days are warm, and nights are cool. Wide variations in precipitation, temperature, and humidity are characteristic. Sunshine throughout the year averages about 60 percent of the possible amount. It ranges from about 45 percent of the possible amount in winter to 70 percent in summer. About 220 days each year are either clear or are only partly cloudy. In summer, the relative humidity ranges from 85 percent early in the morning to 50 percent late in the afternoon. In winter, the average relative humidity is about 75 percent both day and night.

[5] By Alfred A. Skrede, State Climatologist, U.S. Weather Bureau.

Table 10 gives temperature and precipitation data based on records kept at Grafton. Table 11 gives the probability of freezing temperatures after specified dates in spring and before specified dates in fall. Data on temperatures in table 11 are those obtained from instruments placed in a shelter.

The average annual precipitation is more than 18 inches, but the amount has ranged from slightly more than 10 inches, in 1897, to nearly 28 inches, in 1909. Three-fourths of the annual precipitation falls during the growing season of April through September. About 45 percent falls during the months of May through July. Precipitation in summer is usually in the form of thunderstorms. About 30 thunderstorms are reported each year. Precipitation of 0.10 inch per day can be expected on an average of 44 days per year. Rainfall of 1.00 inch or more per day occurs about three times each year. Rainfall with intensities of the following amounts can be expected to occur once in 2 years (*8*): 0.85 inch in 30 minutes; 1.00 inch in 1 hour; 1.25 inches in 2 hours; 1.40 inches in 3 hours; 1.50 inches in 6 hours; 1.85 inches in 12 hours; and 2.00 inches in 24 hours.

The annual amount of snowfall has ranged from 84 inches, which fell in 1947–48, to only 8 inches in 1957–58, but the yearly average is about 36 inches. A measureable amount of snow can be expected 4 years in 10 in October; 1 year in 2 in April; 1 year in 10 in May; and every year during the months of November through March. The average date of the first snowfall of 1 inch or more is the second week in November. Table 10 shows the average number of days of snow cover to be expected for each month.

Table 10.—*Temperature and precipitation data*

[All data from U.S. Weather Bureau Station at Grafton, Walsh County, N. Dak.]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One year in 10 will have—		Days with snow cover	Average depth of snow on days with snow cover [1]
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	° F.	*° F.*	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	14	−7	37	−30	0.62	0.2	1.5	26	11
February	19	−2	40	−26	.57	.2	1.4	23	11
March	33	13	54	−11	.72	.1	1.3	15	8
April	53	29	75	14	1.37	.3	2.5	3	4
May	69	40	85	27	2.05	.7	3.9	(2)	0
June	77	50	90	38	3.28	1.7	5.4	0	0
July	83	56	95	45	2.69	1.4	5.0	0	0
August	82	53	94	40	2.60	.8	4.2	0	0
September	71	44	88	29	2.12	.6	4.7	0	0
October	57	33	75	17	1.13	.3	2.5	1	0
November	36	17	56	−7	.81	.2	1.5	11	(3)
December	31	2	41	−21	.54	.2	1.2	22	3
Year	51	27	[4] 99	[5] −33	18.50	13.0	24.4	101	6

[1] Based on a record of 12 years: 1951–62.
[2] Less than 1 day.
[3] Less than 1 inch.
[4] Average annual highest temperature.
[5] Average annual lowest temperature.

TABLE 11.—*Probability of freezing temperatures later than specified dates in spring and earlier than specified dates in fall*

Probability	Dates for given probability and temperature				
	32° F. or lower	28° F. or lower	24° F. or lower	20° F. or lower	16° F. or lower
Spring:					
10 percent	June 5	May 20	May 14	May 5	April 26
25 percent	May 29	May 13	May 6	April 28	April 18
50 percent	May 22	May 6	April 28	April 19	April 9
75 percent	May 15	April 29	April 20	April 11	March 31
90 percent	May 8	April 22	April 12	April 3	March 23
Fall:					
10 percent	September 7	September 15	September 25	October 4	October 12
25 percent	September 13	September 21	October 3	October 12	October 20
50 percent	September 19	September 28	October 11	October 21	October 29
75 percent	September 25	October 5	October 19	October 30	November 7
90 percent	October 1	October 11	October 27	November 7	November 15

Figure 12 represents the moisture balance in Walsh County. Data for pan evaporation are based on records kept at the Devils Lake Weather Bureau office in Ramsey County, using a Class A pan. Potential evapotranspiration is estimated according to the Thornthwaite method (*4*). During the growing season of April through September, the average precipitation is 14.11 inches and pan evaporation is 31.75 inches. The Thornthwaite estimate of potential evapotranspiration is 23.19 inches, but the true potential evapotranspiration is probably somewhere between the figure of 31.75 inches and 23.19 inches. It is probably closer to 31.75 inches than 23.19 inches.

The average maximum temperature during the 3-month period of June through August is 81° F. Temperatures of 90 degrees or higher occur on an average of 16 days each year, and 6 of these days generally fall in July and 6 in August. The average temperature during the months of December through February is about 7.6° F., but maximum temperatures on 16 days during these 3 months exceed 32 degrees. During cold spells, temperatures drop to zero or below on an average of 62 days each year.

The average date of the last temperature of 32 degrees in spring is May 22 (*2*), and that for the first in fall is September 19. The average freeze-free period is 120 days per year. The probability of the last occurrence of freezing temperatures in spring and the first in fall can be determined from table 11. For example, there is a 25-percent chance that a temperature of 32 degrees or lower will occur after May 29 in spring, or that it will occur after that date once in 4 years. Frost can occur on the ground when the temperature inside an elevated instrument shelter is higher than 32 degrees. Variations of as much as several days from the average dates shown in table 11 can be expected because of the local effects of terrain. In small depressions that are well protected from air movement, the last freezing temperature is somewhat later in spring and the first freezing temperature is somewhat earlier in fall than the dates shown in table 11.

Hail accompanies two or three thunderstorms each year, but it causes only slight damage. Walsh County ranks ninth among counties in the State in percentage of area insured for hail damage. According to the North Dakota State Hail Insurance Department, 9.5 percent of the area insured was damaged 5 percent or more by hail in the period 1941–61. The proportion was as high as 42 percent in 1959.

Records kept at the Weather Bureau office at Devils Lake show the following distribution of days on which hail has fallen:

Month	*Percentage occurrence of hail days*
April	13
May	18
June	18
July	22
August	17
Other months	12

At Grand Forks, N. Dak., where wind direction and velocity are typical of those in Walsh County, winds blow mainly from the north-northwest in the period of November through May, and from the southeast in the period of June through October. The average windspeed is 11.8 miles per hour. Winds are strongest in summer, during which time a maximum of 73 miles per hour was recorded on one occasion.

Farming

Walsh County had a total of 1,557 farms in 1964, and the average size of farm was 527.6 acres. In 1964, crops were harvested from 468,971 acres; 186,620 acres was in cultivated summer fallow; 28,421 acres was woodland pastured or not pastured; and 46,000 acres was in hay or pasture.

Wheat, barley, potatoes, and flax are the main crops grown. Hard red spring wheat, which occupied the largest acreage in 1964, was harvested from 165,788 acres. Hard red spring wheat is generally planted in fields that were summer fallowed the year before. Where this crop is planted in fallowed fields, the accepted practice is to apply fertilizer that is high in content of phosphorus. Where hard red spring wheat is planted in nonfallowed fields, the accepted practice is to apply fertilizer that is high in content of nitrogen and phosphorus. Fields are sprayed to control weeds and insects before the wheat heads out. Wheat is susceptible to several varieties of stem rust.

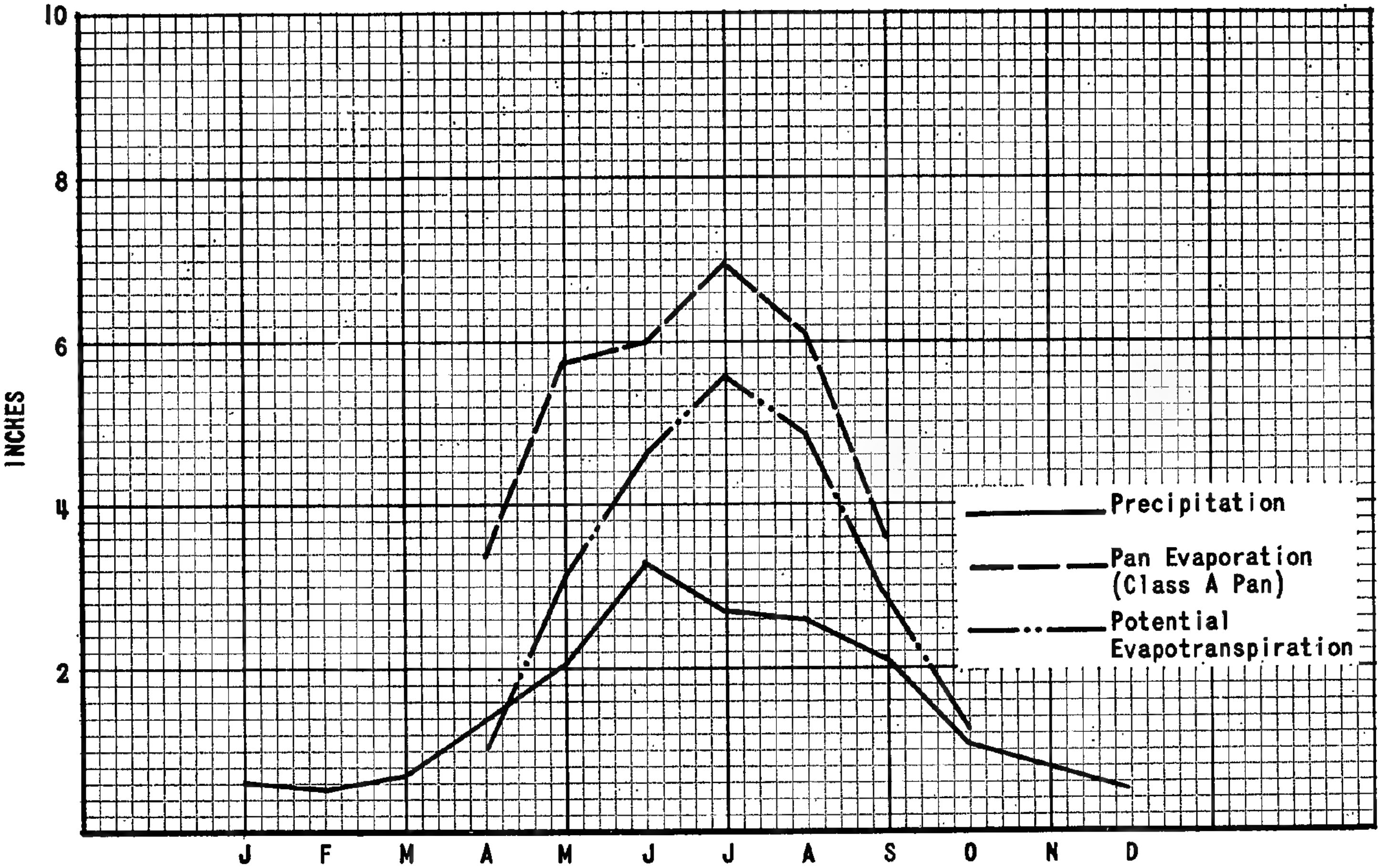

Figure 12.—**Precipitation, pan evaporation, and potential evapotranspiration in Walsh County, N. Dak.**

Durum wheat was harvested from 47,769 acres, mainly in the western part of the county, in 1964. This grain is planted in fields that were summer fallowed the previous year, and it is fertilized and sprayed in about the same way as hard red spring wheat. Durum wheat has the disadvantage of requiring ideal weather during harvest if it is to grade out as No. 1 grain. This crop is highly susceptible to stem rust.

Barley for grain was harvested from 127,710 acres in 1964. About 90 percent of the crop was graded as malting barley. This grain generally follows wheat in the cropping system, and it is fertilized by using a blend of nitrogen and phosphate fertilizer. The acreage used for growing barley varies considerably, according to changes in the Federal government's feed-grain programs.

Potatoes were harvested from 37,582 acres in 1964. This crop was sold as certified seed, as raw material for processing, and as edible tubers for table use. Certified seed potatoes from Walsh County are sold throughout the United States. Most potatoes marketed for processing are grown on a contract basis. Potatoes are usually planted in fields that were summer fallowed the year before, but they can be grown successfully in clean stubble fields. Potatoes are a very desirable row crop because cultivation allows farms to control weeds. The disadvantage in growing potatoes is that only a small amount of plant residue is returned to the soils during harvest, and the soils are left loose and pulverized. As a result, bare fields where potatoes have been harvested are highly susceptible to soil blowing until they are rough tilled or are covered with snow.

Flax was grown for seed on 29,684 acres in 1964. Flax is used as an alternate crop for barley in the cropping system, but it is also a good cash crop in most years. Flax is also used as a nurse crop for alfalfa or sweet clover. It is planted in spring in clean stubble or in fields that have been cultivated several times to control wild oats.

Sugar beets were grown on 10,800 acres in 1964. Farmers grow sugar beets under contract with the American Crystal Sugar Company, and the annual acreage has been increasing. The crop is planted in fields that were summer fallowed the year before. Thinning the young plants and controlling weeds require a large amount of labor. Farmers realize their highest net income per acre from the production of sugar beets.

Sunflowers, tame mustard, and rye are grown on small acreages each year.

A total of 28,855 cattle and calves; 4,414 hogs and pigs; 4,166 sheep and lambs; and 37,111 chickens 4 months old and older were in Walsh County in 1964. Most dairy products are used locally, but some are sold outside the county. Calves are fed on the farm if hay is plentiful. Otherwise, they are sold as feeders.

The County Agricultural High School is located in Park River. Students learn about farming through instruction

and through the operation of an 80-acre farm owned by the school. They participate in crop demonstrations and variety trials, which are conducted in cooperation with the North Dakota Agricultural Experiment Station.

Watershed Protection and Flood Control

Most of Walsh County is in the watersheds of the Park River and the Forest River. Some areas, however, drain directly into the Red River. Others, in the extreme western part of the county, drain into the basin of Devils Lake.

Public Law 566, as amended, provides technical and construction assistance to local people in need of watershed protection and prevention of flooding. In most areas of Walsh County, flooding is a hazard that involves many State and Federal agencies. The tributaries of the Park and Forest Rivers that flow through the rolling ground moraine in the western part of the county flood areas of adjacent land. Streams in this area generally flow eastward in channels that diminish in size where they cross old glacial lake beach lines. Still farther east, these streams flow onto the lake plain, which is nearly level. On the lake plain, streams frequently overflow, resulting in losses of soil and damage to crops and other property.

Adequate protection from flooding is possible where all feasible dam sites above the beach lines and delta deposits are developed, and where stream channels below the beach lines and delta deposits are enlarged and floodways are established along streams. The multiple-use feature of watershed and flood-control work includes improvement in soil-and-water management throughout the watershed, and it provides additional resources that lead to more opportunities for fishing, hunting, and other types of recreation.

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Glossary

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well-aerated soil is similiar to that in the atmosphere; but that in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Boulder. A rounded or partly rounded stone more than 10 inches in diameter.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Cobblestone. A rounded or partly rounded fragment of rock 3 to 10 inches in diameter.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Dispersion, soil. Deflocculation of the soil and its suspension in water.

Drainage. See Natural soil drainage.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Flood plain. Nearly level land, consisting of stream sediment, that borders a stream and is subject to flooding unless protected artificially.

Glacial drift (geology). Rock material transported by glacial ice and then deposited; also includes the assorted and unassorted materials deposited by streams flowing from glaciers.

Glacial outwash (geology). Cross-bedded gravel, sand, and silt deposited by melt water as it flowed from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gravel. Rounded or subrounded stones up to 3 inches in diameter.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residue.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension, and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Natural soil drainage. Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and in Podzolic soils commonly have mottling below 6 to 16 inches, in the lower A horizon and in the B and C horizons.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Phase, soil. A subdivision of a soil series or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape.

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See also Horizon, soil.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strong acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Saline-alkali soil. A soil that contains a harmful concentration of salts and exchangeable sodium; or contains harmful salts and has a highly alkaline reaction; or contains harmful salts and exchangeable sodium and is strongly alkaline in reaction. The salts, exchangeable sodium, and alkaline reaction occur in the soil in such location that growth of most crop plants is less than normal.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable soduim.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent of more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles, less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: *Very coarse sand* (2.0 to 1.0 millimeter); *coarse sand* (1.0 to 0.5 millimeter); *medium sand* (0.5 to 0.25 millimeter); *fine sand* (0.25 to 0.10 millimeter); *very fine sand* (0.10 to 0.05 millimeter); *silt* (0.05 to 0.002 millimeter); and *clay* (less than 0.002 millimeter). The separates recognized by the International Society of Soil Science are as follows: I (2.0 to 0.2 millimeter); II (0.2 to 0.02 millimeter); III (0.02 to 0.002 millimeter); IV (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the parent material, and in which the processes of soil formation are active. The solum in a mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Stones. Rock fragments greater than 10 inches in diameter if rounded, and greater than 15 inches along the longer axis if flat.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which it belongs. In referring to a capability unit, read the introduction of the section the unit is in for general information about its management. Other information is given in tables as follows:

Acreage and extent, table 1, page 13.
Predicted yields, table 2, page 76.
Soils and their suitability for adapted trees, by windbreak sites, table 3, page 78.
Suitability of soil associations for wildlife, table 4, page 82.
Engineering uses of the soils, tables 5, 6, 7, and 8, pages 84 through 114.

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Windbreak site Number
An	Antler stony clay loam	14	VIs-Si	73	10
Ao	Antler clay loam	14	IIe-4L	63	1
As	Arveson-Fossum fine sandy loams	15	IIIwe-3	69	2
At	Arveson-Fossum loams	15	IIw-4L2	65	2
AuA	Arvilla sandy loam, nearly level	16	IIIes-3	67	6
AuB	Arvilla sandy loam, gently sloping	16	IIIes-3	67	6
BaC	Barnes loam, rolling	17	IIIe-6	67	3
BaC2	Barnes loam, rolling, eroded	17	IIIe-6	67	3
BbD2	Barnes-Buse loams, hilly, eroded	17	IVe-6	71	3
Be	Barnes-Buse stony loams	17	VIs-Si	73	10
BgC	Barnes-Renshaw loams, rolling	17			
	Barnes part	--	IIIes-5	68	3
	Renshaw part	--	IIIes-5	68	6
BhD	Barnes-Sioux complex, hilly	17			
	Barnes part	--	VIs-SwG	74	3
	Sioux part	--	VIs-SwG	74	10
BkB	Barnes-Svea loams, gently undulating	18			
	Barnes part	--	IIe-6	64	3
	Svea part	--	IIe-6	64	1
BkB2	Barnes-Svea loams, gently undulating, eroded	18			
	Barnes part	--	IIe-6	64	3
	Svea part	--	IIe-6	64	1
BlA	Barnes-Svea stony loams, nearly level	18	VIs-Si	73	10
BlC	Barnes-Svea stony loams, rolling	18	VIs-Si	73	10
Bm	Bearden silt loam	19	IIe-4L	63	1
BnA	Bearden silty clay loam, level	19	IIe-4L	63	1
BnC	Bearden silty clay loam, sloping	19	IIe-4L	63	1
Bo	Bearden silty clay loam, fans	19	IIe-4L	63	1
Br	Bearden silty clay loam, saline	20	IIIws-4	70	9
Bs	Bearden silty clay loam, gravelly substratum	20	IIw-4L	65	1
Bt	Bearden silty clay	20	IIwe-4	66	1
Bu	Benoit loam	21	Vw-WL	72	10
Bv	Borup silt loam	21	IIw-6	66	2
BwB	Brantford-Vang loams, gently sloping	22			
	Brantford part	--	IIIes-5	68	6
	Vang part	--	IIIes-5	68	3
BwC	Brantford-Vang loams, sloping	22			
	Brantford part	--	IIIes-5	68	6
	Vang part	--	IIIes-5	68	3
ByC	Buse-Barnes loams, rolling	23			
	Buse part	--	IVe-4L	71	8
	Barnes part	--	IVe-4L	71	3
ByD	Buse-Barnes loams, hilly	23	VIe-Si	73	8
ByE	Buse-Barnes loams, steep	23	VIe-Si	73	10
CaA	Cashel silty clay, nearly level	24	IIe-4	63	1
CaB	Cashel silty clay, gently sloping	24	IIe-4	63	1
CcE	Cashel soils, steep	24	VIIIe-1	74	10
Cd	Cavour complex	25	VIs-Cp	73	9
Ce	Coe soils	25	VIs-SwG	74	10
Cf	Colvin silt loam	26	IIw-6	66	2

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Windbreak site Number
Lr	LaPrairie silty clay loam	44	IIc-6	63	1
Lu	Ludden silty clay	44	IIw-4	64	10
Ly	Ludden and Ryan soils	44	VIs-SS	74	10
Mk3	Maddock-Hecla complex, severely eroded	45			
	Maddock part	--	VIe-Sa	73	5
	Hecla part	--	VIe-Sa	73	1
Mn	Manfred soils	46			
	Drained	--	Vw-WL	72	2
	Undrained	--	Vw-WL	72	10
Oa	Ojata soils	46	VIs-SS	74	10
OeA	Overly silt loam, level	47	IIc-6	63	1
OlA	Overly silty clay loam, level	47	IIc-6	63	1
OlB	Overly silty clay loam, gently sloping	47	IIe-6	64	1
OlC	Overly silty clay loam, sloping	47	IIIe-6	67	1
Om	Overly silty clay loam, fans	47	IIc-6	63	1
OvA	Overly silty clay, level	47	IIe-4	63	1
Ow	Overly silty clay, fans	48	IIe-4	63	1
Pa	Parnell silty clay loam	48			
	Drained	--	Vw-WL	72	2
	Undrained	--	Vw-WL	72	10
Pt	Parnell and Tonka soils	48	IIw-6	66	2
Pu	Perella silty clay loam	49	IIw-6	66	2
Ra	Rauville soils	49	Vw-WL	72	10
ReA	Renshaw loam, nearly level	50	IIIs-5	68	6
ReB	Renshaw loam, gently sloping	50	IIIes-5	68	6
Ro	Rockwell fine sandy loam	51	IIIe-3M	67	2
Sr	Sioux-Renshaw complex	52			
	Sioux part	--	VIs-SwG	74	10
	Renshaw part	--	VIs-SwG	74	6
SsE	Sioux and Renshaw soils, steep	52			
	Sioux part	--	VIs-SwG	74	10
	Renshaw part	--	VIs-SwG	74	6
SuA	Svea-Barnes loams, nearly level	53	IIc-6	63	1
SvA	Svea-Cresbard loams, nearly level	53			
	Svea part	--	IIIs-P	69	1
	Cresbard part	--	IIIs-P	69	4
ToA	Towner sandy loam, level	54	IIIe-3M	67	1
Un	Ulen sandy loam	55	IIIe-3	67	1
Va	Vallers loam, saline	56	IIIws-4	70	9
Vh	Vallers-Hamerly loams	56			
	Vallers part	--	IIw-4L	65	9
	Hamerly part	--	IIw-4L	65	1
Vm	Vallers-Hamerly stony loams	56	Vsw-Sb	72	10
VnA	Vang-Brantford loams, nearly level	57			
	Vang part	--	IIIs-5	68	3
	Brantford part	--	IIIs-5	68	6
Wa	Wahpeton silty clay	57	IIe-4	63	1
WhC	Walsh loam, sloping	58	IIIe-6	67	1
WlA	Walsh loam, sand substratum, nearly level	58	IIc-6	63	1
WlB	Walsh loam, sand substratum, gently sloping	58	IIe-6	64	1
Wm	Walsh silt loam	58	IIc-6	63	1
WnA	Walsh clay loam, level	58	IIe-4	63	1
WoB	Waukon loam, gently undulating	59	IIe-6	64	1
WoD	Waukon loam, strongly rolling	59	IVe-6	71	3
ZgC	Zell-Gardena silt loams, sloping	60			
	Zell part	--	IVe-4L	71	8
	Gardena part	--	IVe-4L	71	1
ZgE	Zell-Gardena silt loams, steep	60			
	Zell part	--	VIe-Si	73	8
	Gardena part	--	VIe-Si	73	1

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Windbreak site Number
Ch	Colvin silty clay loam	26	IIw-6	66	2
Co	Colvin silty clay loam, very wet	26			
	Drained	--	Vw-WL	72	2
	Undrained	--	Vw-WL	72	10
DdA	Divide loam, level	27	IIIs-4L	68	2
EbA	Edgeley loam, nearly level	28	IIc-6	63	3
EbB	Edgeley loam, gently undulating	28	IIe-6	64	3
EbC	Edgeley loam, undulating	28	IIIe-6	67	3
EmA	Embden sandy loam, level	29	IIIe-3	67	1
EmB	Embden sandy loam, gently undulating	29	IIIe-3	67	1
EmC	Embden sandy loam, sloping	29	IIIe-3	67	1
EnA	Embden loam, level	29	IIe-5	64	1
Fa	Fairdale silt loam	30	IIc-6	63	1
FaB	Fairdale silt loam, gently sloping	30	IIe-6	64	1
Fd	Fairdale silt loam, occasionally flooded	30	IIc-6	63	1
Fe	Fairdale and LaPrairie soils, channeled	30	VIe-Si	73	10
FfA	Fargo silty clay, nearly level	31	IIwe-4	66	1
Fg	Fargo silty clay, depressional	31	IIw-4	64	2
FhA	Fargo-Hegne silty clays, level	31	IIwe-4	66	1
FhB	Fargo-Hegne silty clays, gently sloping	31	IIe-4	63	1
GaA	Gardena silt loam, nearly level	32	IIe-5	64	1
GaB	Gardena silt loam, gently sloping	33	IIe-5	64	1
Gb	Gilby loam	33	IIe-4L	63	1
Ge	Gilby loam, wet	33	IIw-4L	65	2
Gh	Gilby stony loam	34	VIs-Si	73	10
GlA	Glyndon silt loam, level	34	IIe-4L	63	1
GlB	Glyndon silt loam, gently sloping	34	IIe-4L	63	1
Gm	Glyndon silt loam, moderately saline	34	IIIws-4	70	9
Gr	Grano silty clay, very wet	35			
	Drained	--	Vw-WL	72	2
	Undrained	--	Vw-WL	72	10
Gs	Grano-Hegne silty clays	35			
	Grano part	--	IIwe-4	66	2
	Hegne part	--	IIwe-4	66	1
Ha	Hamar and Ulen loamy sands	36			
	Hamar part	--	IVe-2	70	2
	Ulen part	--	IVe-2	70	1
Hd	Hamar and Ulen sandy loams	36			
	Hamar part	--	IIIwe-3	69	2
	Ulen part	--	IIIwe-3	69	1
He	Hamerly-Cresbard loams	37			
	Hamerly part	--	IIIs-P	69	1
	Cresbard part	--	IIIs-P	69	4
HgA	Hamerly-Svea loams, nearly level	37	IIe-4L	63	1
HgB	Hamerly-Svea loams, gently undulating	37	IIe-4L	63	1
Hh	Hattie silty clay, lacustrine	38	IVe-4	71	8
HlA	Hecla loamy sand, nearly level	38	IVe-2	70	1
HlB	Hecla loamy sand, gently undulating	38	IVe-2	70	1
HmA	Hegne-Fargo silty clays, nearly level	39	IIwe-4	66	1
HmB	Hegne-Fargo silty clays, gently sloping	39	IIe-4	63	1
Hn	Hegne silty clay, saline	39	IIIws-4	70	9
Hs	Hegne silty clay, strongly saline-alkali	40	VIs-SS	74	10
Kn	Kloten complex	40	VIs-Sw	74	10
La	Lamoure soils, moderately saline	42	IIIws-4	70	9
LeA	Lankin loam, level	42	IIc-6	63	1
Lk	Lankin clay loam	42	IIc-6	63	1
LnA	Lankin and Svea loams, nearly level	43	IIc-6	63	1
LnB	Lankin and Svea loams, gently sloping	43	IIe-6	64	1
Lp	LaPrairie silt loam	43	IIc-6	63	1

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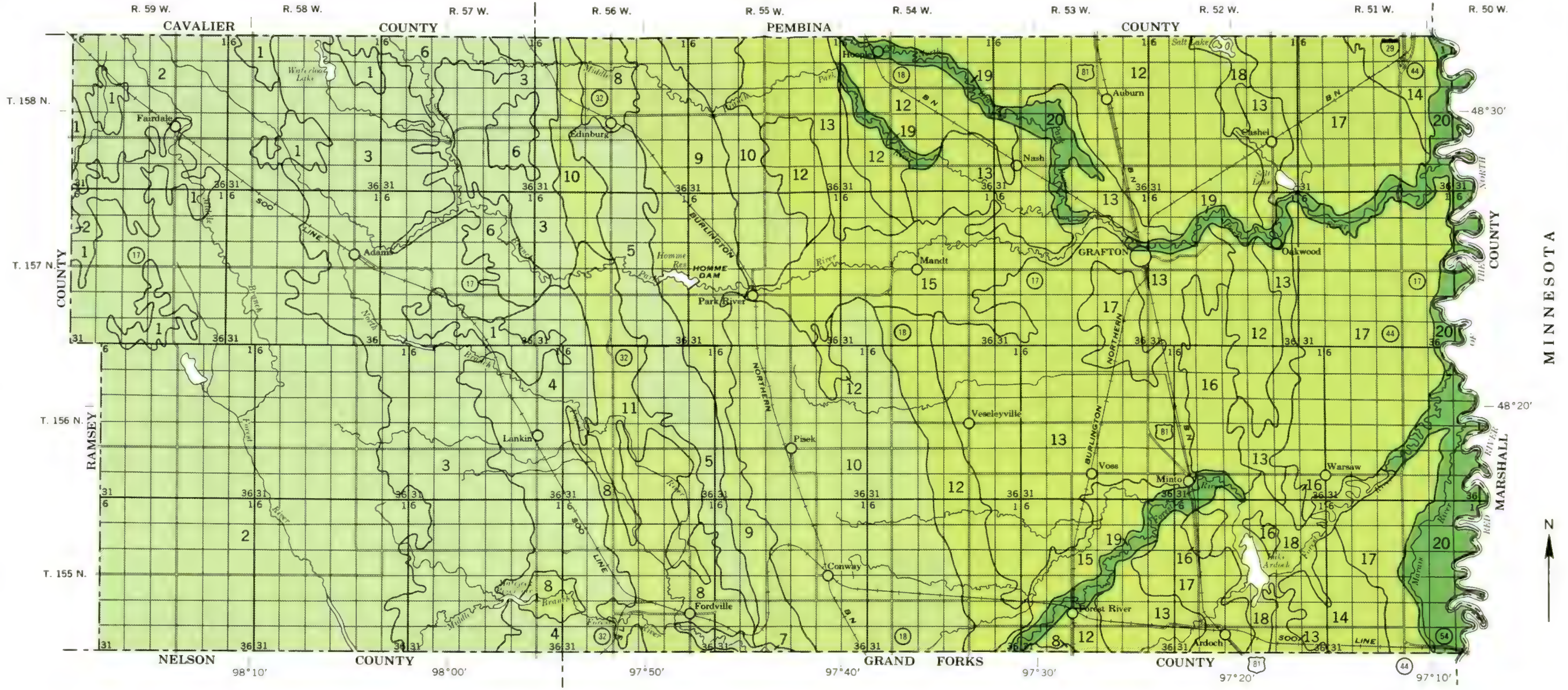


SOIL ASSOCIATIONS *

SOILS OF THE GLACIAL TILL PLAINS

1 Cresbard-Hamerly-Svea association: Deep, nearly level, moderately well drained and somewhat poorly drained loamy soils

2 Hamerly-Svea-Barnes association: Deep, nearly level to rolling, somewhat poorly drained to well-drained loamy soils

3 Barnes-Svea-Parnell association: Deep, nearly level to rolling, moderately well drained and well drained loamy soils and nearly level, deep, very poorly drained loamy and clayey soils

4 Svea-Barnes association: Deep, nearly level and gently sloping, moderately well drained and well drained loamy soils

5 Barnes-Buse association: Deep, gently undulating to steep, well-drained and excessively drained loamy soils on the Edinburg moraine

6 Kloten-Edgeley association: Shallow to deep, nearly level to undulating and steep, well-drained loamy soils over shale bedrock

7 Buse-Fairdale association: Deep, nearly level to steep, excessively drained and moderately well drained loamy soils

SOILS OF THE OUTWASH, INTERBEACH, DELTA, AND VALLEY AREAS

8 Renshaw-Brantford-Sioux association: Shallow, nearly level to steep, excessively drained and well-drained loamy soils underlain by sand and gravel

9 Embden-Hecla-Ulen association: Deep, nearly level to sloping, moderately well drained and somewhat poorly drained loamy and sandy soils

10 Lankin-Gilby association: Deep, nearly level to gently sloping, somewhat poorly drained and poorly drained loamy soils

11 Walsh association: Deep, level to sloping, well drained and moderately well drained loamy soils formed in shaly alluvium

SOILS OF THE GLACIAL LAKE PLAIN

12 Glyndon-Gardena association: Deep, nearly level to gently sloping, moderately well drained and somewhat poorly drained loamy soils

13 Bearden-Overly association: Deep, nearly level to gently sloping, somewhat poorly drained and moderately well drained silty soils

14 Bearden-Glyndon association: Deep, nearly level, moderately well drained and somewhat poorly drained, calcareous clayey and loamy soils

15 Overly-Bearden fans association: Deep, nearly level, moderately well drained and somewhat poorly drained silty and clayey soils on alluvial fans

16 Bearden-Glyndon moderately saline association: Deep, nearly level, somewhat poorly drained and moderately well drained silty and loamy soils that are saline

17 Hegne-Fargo association: Deep, nearly level to gently sloping, poorly drained clayey soils

18 Ojata-Hegne saline association: Deep, nearly level, poorly drained silty and clayey soils that are strongly saline

SOILS OF THE FLOOD PLAINS AND LOW TERRACES

19 Fairdale-LaPrairie association: Deep, nearly level to gently sloping, moderately well drained loamy soils on flood plains

20 Wahpeton-Cashel-Fargo association: Deep, nearly level to gently sloping, moderately well drained to poorly drained clayey soils on flood plains and low terraces

* Texture is that of surface layer

Published 1971

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

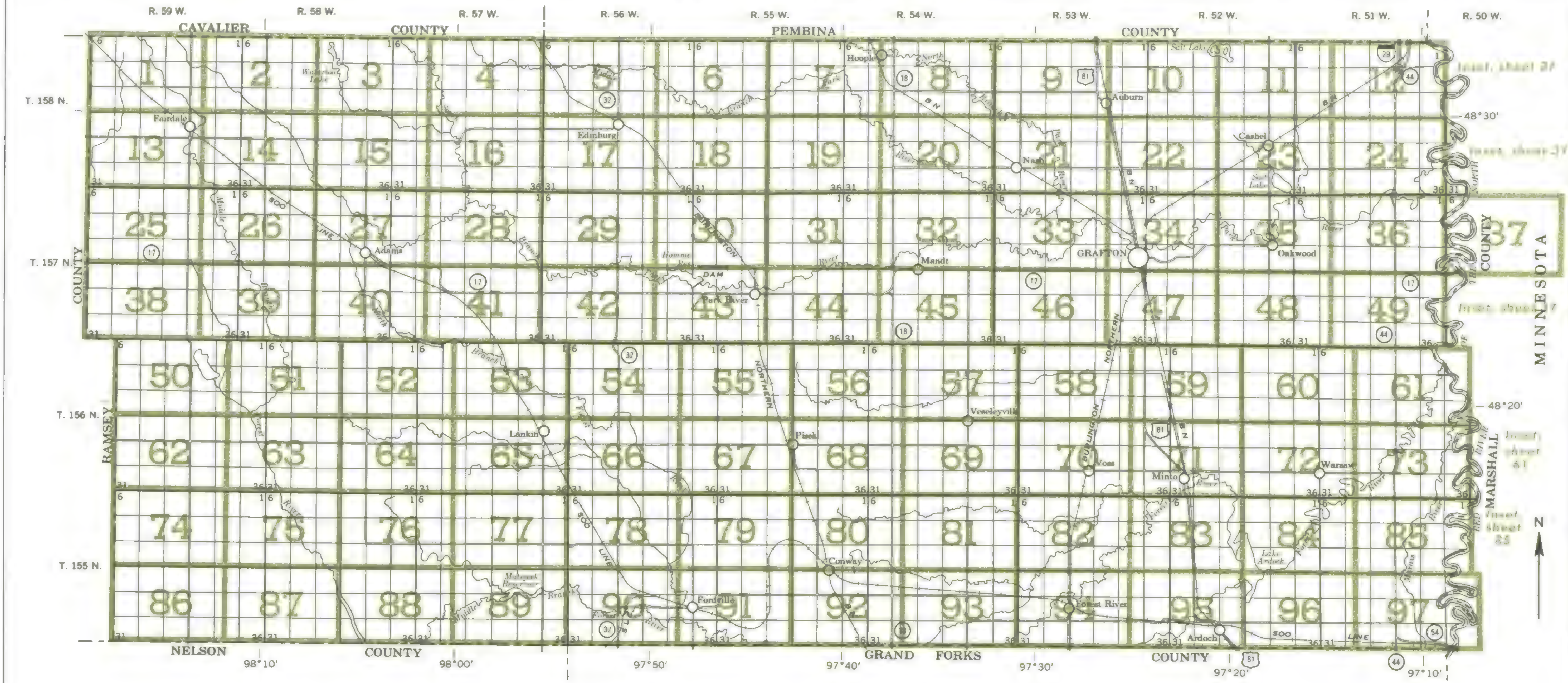
GENERAL SOIL MAP

WALSH COUNTY, NORTH DAKOTA

Scale 1:253,440

1 0 1 2 3 4 Miles

This map is for general planning. It shows only the major soils and does not contain sufficient detail for operational planning.



INDEX TO MAP SHEETS

WALSH COUNTY, NORTH DAKOTA

Scale 1:253,440

1 0 1 2 3 4 Miles

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, or E, shows the slope. Most symbols without a slope letter are those of nearly level soils, but some are for soils that have a considerable range in slope. The final number, 2 or 3, in a symbol shows that the soil is eroded or severely eroded.

SYMBOL	NAME
An	Antler stony clay loam
Ao	Antler clay loam
As	Arveson-Fossum fine sandy loams
At	Arveson-Fossum loams
AuA	Arvilla sandy loam, nearly level
AuB	Arvilla sandy loam, gently sloping
BaC	Barnes loam, rolling
BaC2	Barnes loam, rolling, eroded
BbD2	Barnes-Buse loams, hilly, eroded
Be	Barnes-Buse stony loams
BgC	Barnes-Renshaw loams, rolling
BhD	Barnes-Sioux complex, hilly
BkB	Barnes-Svea loams, gently undulating
BkB2	Barnes-Svea loams, gently undulating, eroded
BlA	Barnes-Svea stony loams, nearly level
BlC	Barnes-Svea stony loams, rolling
Bm	Bearden silt loam
BnA	Bearden silty clay loam, level
BnC	Bearden silty clay loam, sloping
Bo	Bearden silty clay loam, fans
Br	Bearden silty clay loam, saline
Bs	Bearden silty clay loam, gravelly substratum
Bt	Bearden silty clay
Bu	Benoit loam
Bv	Borup silt loam
BwB	Brantford-Vang loams, gently sloping
BwC	Brantford-Vang loams, sloping
ByC	Buse-Barnes loams, rolling
ByD	Buse-Barnes loams, hilly
ByE	Buse-Barnes loams, steep
CaA	Cashel silty clay, nearly level
CaB	Cashel silty clay, gently sloping
CcE	Cashel soils, steep
Cd	Cavour complex
Ce	Coe soils
Cf	Colvin silt loam
Ch	Colvin silty clay loam
Co	Colvin silty clay loam, very wet
DdA	Divide loam, level
EbA	Edgeley loam, nearly level
EbB	Edgeley loam, gently undulating
EbC	Edgeley loam, undulating
EmA	Embden sandy loam, level
EmB	Embden sandy loam, gently undulating
EmC	Embden sandy loam, sloping
EnA	Embden loam, level
Fa	Fairdale silt loam
FaB	Fairdale silt loam, gently sloping
Fd	Fairdale silt loam, occasionally flooded
Fe	Fairdale and LaPrairie soils, channeled
FfA	Fargo silty clay, nearly level
Fg	Fargo silty clay, depressional
FhA	Fargo-Hegne silty clays, level
FhB	Fargo-Hegne silty clays, gently sloping
GaA	Gardena silt loam, nearly level
GaB	Gardena silt loam, gently sloping
Gb	Gilby loam
Ge	Gilby loam, wet
Gh	Gilby stony loam
GlA	Glyndon silt loam, level
GlB	Glyndon silt loam, gently sloping
Gm	Glyndon silt loam, moderately saline
Gr	Grano silty clay, very wet
Gs	Grano-Hegne silty clays
Ha	Hamar and Ulen loamy sands
Hd	Hamar and Ulen sandy loams

SYMBOL	NAME
He	Hamerly-Cresbard loams
HgA	Hamerly-Svea loams, nearly level
HgB	Hamerly-Svea loams, gently undulating
Ht	Hattie silty clay, lacustrine
HlA	Hecla loamy sand, nearly level
HlB	Hecla loamy sand, gently undulating
HmA	Hegne-Fargo silty clays, nearly level
HmB	Hegne-Fargo silty clays, gently sloping
Hn	Hegne silty clay, saline
Hs	Hegne silty clay, strongly saline-alkali
Kn	Kloten complex
La	Lamoure soils, moderately saline
LeA	Lankin loam, level
Lk	Lankin clay loam
LnA	Lankin and Svea loams, nearly level
LnB	Lankin and Svea loams, gently sloping
Lp	LaPrairie silt loam
Lr	LaPrairie silty clay loam
Lu	Ludden silty clay
Ly	Ludden and Ryan soils
Mk3	Maddock-Hecla complex, severely eroded
Mn	Manfred soils
Oa	Ojata soils
OeA	Overly silt loam, level
OlA	Overly silty clay loam, level
OlB	Overly silty clay loam, gently sloping
OlC	Overly silty clay loam, sloping
Om	Overly silty clay loam, fans
OvA	Overly silty clay, level
Ow	Overly silty clay, fans
Pa	Parnell silty clay loam
Pt	Parnell and Tonka soils
Pu	Perella silty clay loam
Ra	Rauville soils
ReA	Renshaw loam, nearly level
ReB	Renshaw loam, gently sloping
Ro	Rockwell fine sandy loam
Sr	Sioux-Renshaw complex
SsE	Sioux and Renshaw soils, steep
SuA	Svea-Barnes loams, nearly level
SvA	Svea-Cresbard loams, nearly level
ToA	Towner sandy loam, level
Un	Ulen sandy loam
Va	Vallers loam, saline
Vh	Vallers-Hamerly loams
Vm	Vallers-Hamerly stony loams
VnA	Vang-Brantford loams, nearly level
Wa	Wahpeton silty clay
WhC	Walsh loam, sloping
WlA	Walsh loam, sand substratum, nearly level
WlB	Walsh loam, sand substratum, gently sloping
Wm	Walsh silt loam
WnA	Walsh clay loam, level
WoB	Waukon loam, gently undulating
WoD	Waukon loam, strongly rolling
ZgC	Zell-Gardena silt loams, sloping
ZgE	Zell-Gardena silt loams, steep

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads

- Dual
- Good motor
- Poor motor
- Trail

Highway markers

- National Interstate
- U. S.
- State or county

Railroads

- Single track
- Multiple track
- Abandoned

Bridges and crossings

- Road
- Trail
- Railroad
- Ferry — FY
- Ford — FORD
- Grade
- R. R. over
- R. R. under

Tunnel

Buildings

- School
- Church

Mine and quarry

Gravel pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

Forest fire or lookout station

Windmill

BOUNDARIES

- National or state
- County
- Reservation
- Land grant
- Small park, cemetery, airport
- Land survey division corners

DRAINAGE

Streams, double-line

- Perennial
- Intermittent

Streams, single-line

- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches — CANAL

Lakes and ponds

- Perennial — water, w
- Intermittent — int

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments

- Bedrock
- Other

Prominent peak

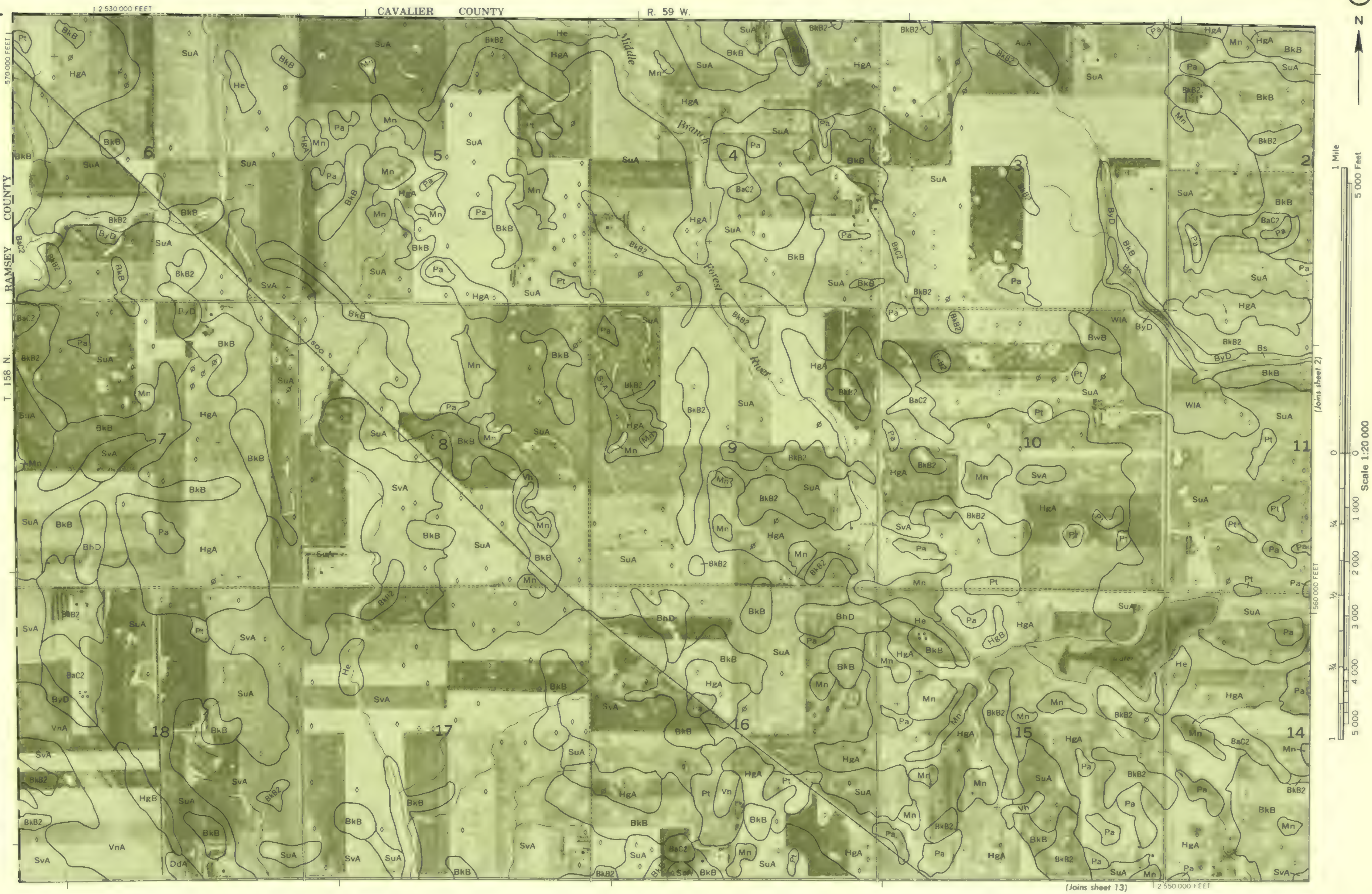
Depressions and sinkholes — Large, Small

- Unclassified

SOIL SURVEY DATA

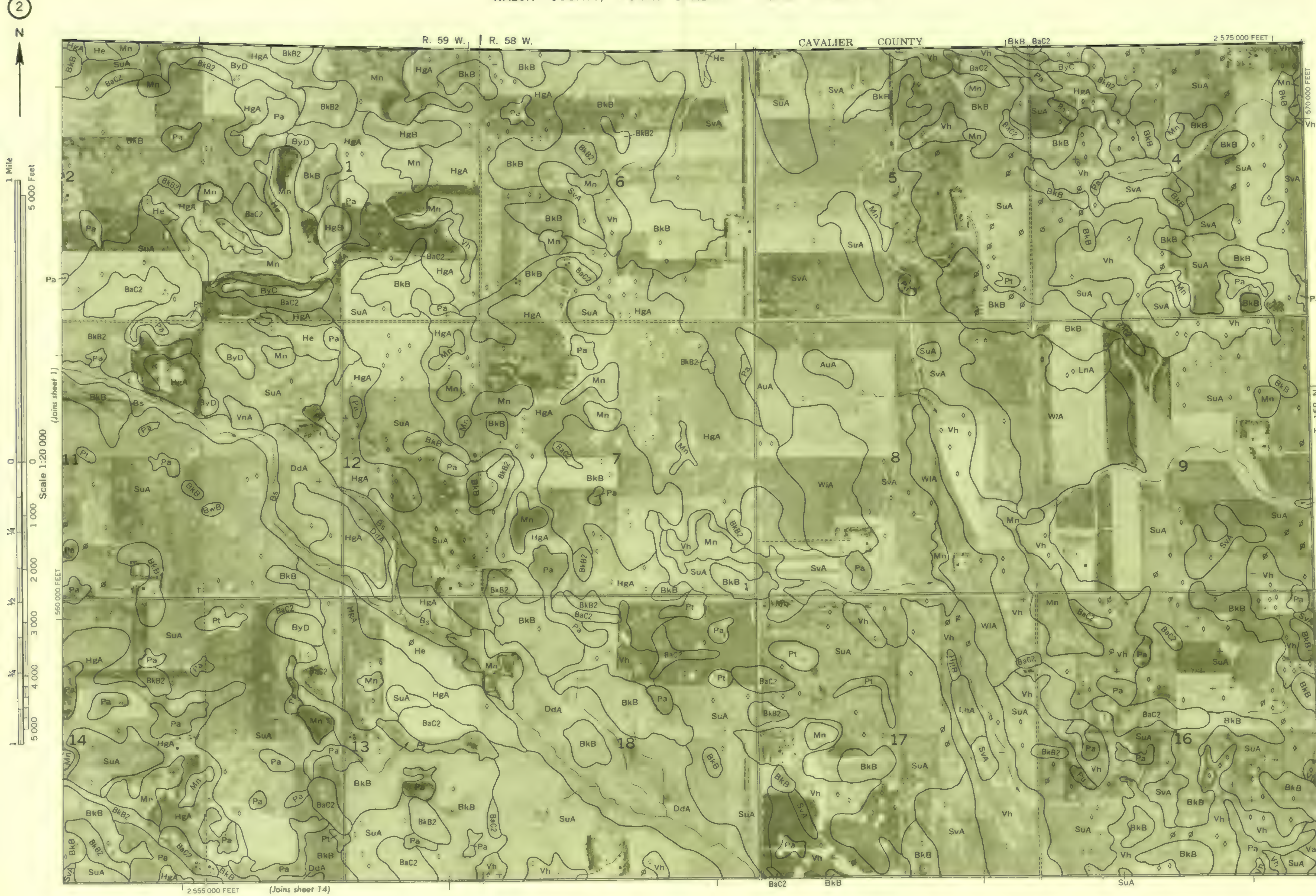
- Soil boundary and symbol — Dx
- Gravel
- Stoniness
  - Stony
  - Very stony
- Shale outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully
- Short steep slope
- Saline spot
- Marsh, with boundary — MARSH
- Gravel pit, with boundary — GRAVEL PIT or G.P.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 1



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 1



WALSH COUNTY, NORTH DAKOTA NO. 2

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WALSH COUNTY, NORTH DAKOTA NO. 3

WALSH COUNTY, NORTH DAKOTA NO. 4

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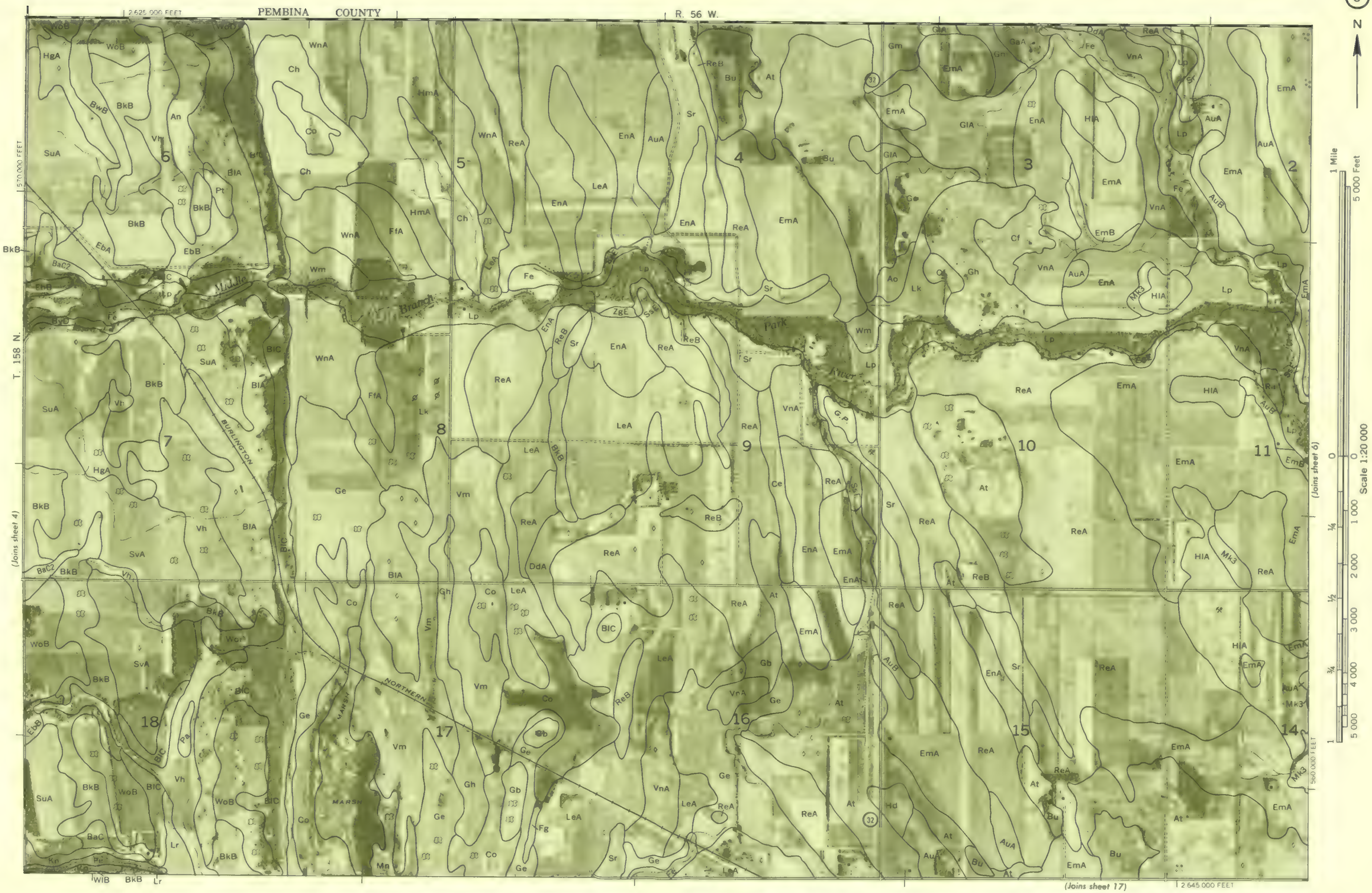
WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 5



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Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 5

6

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 6

WALSH COUNTY, NORTH DAKOTA NO. 6

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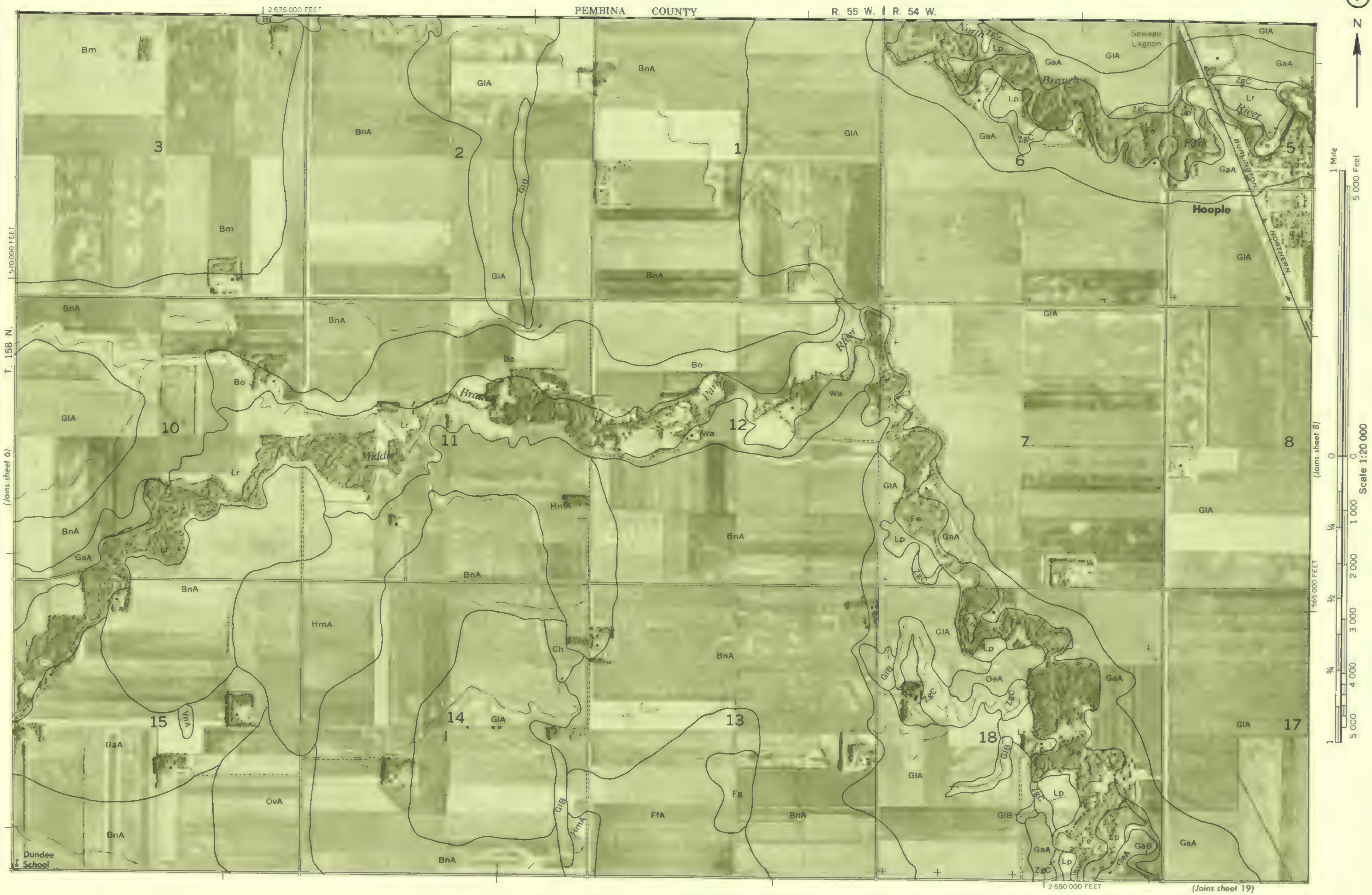
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 7



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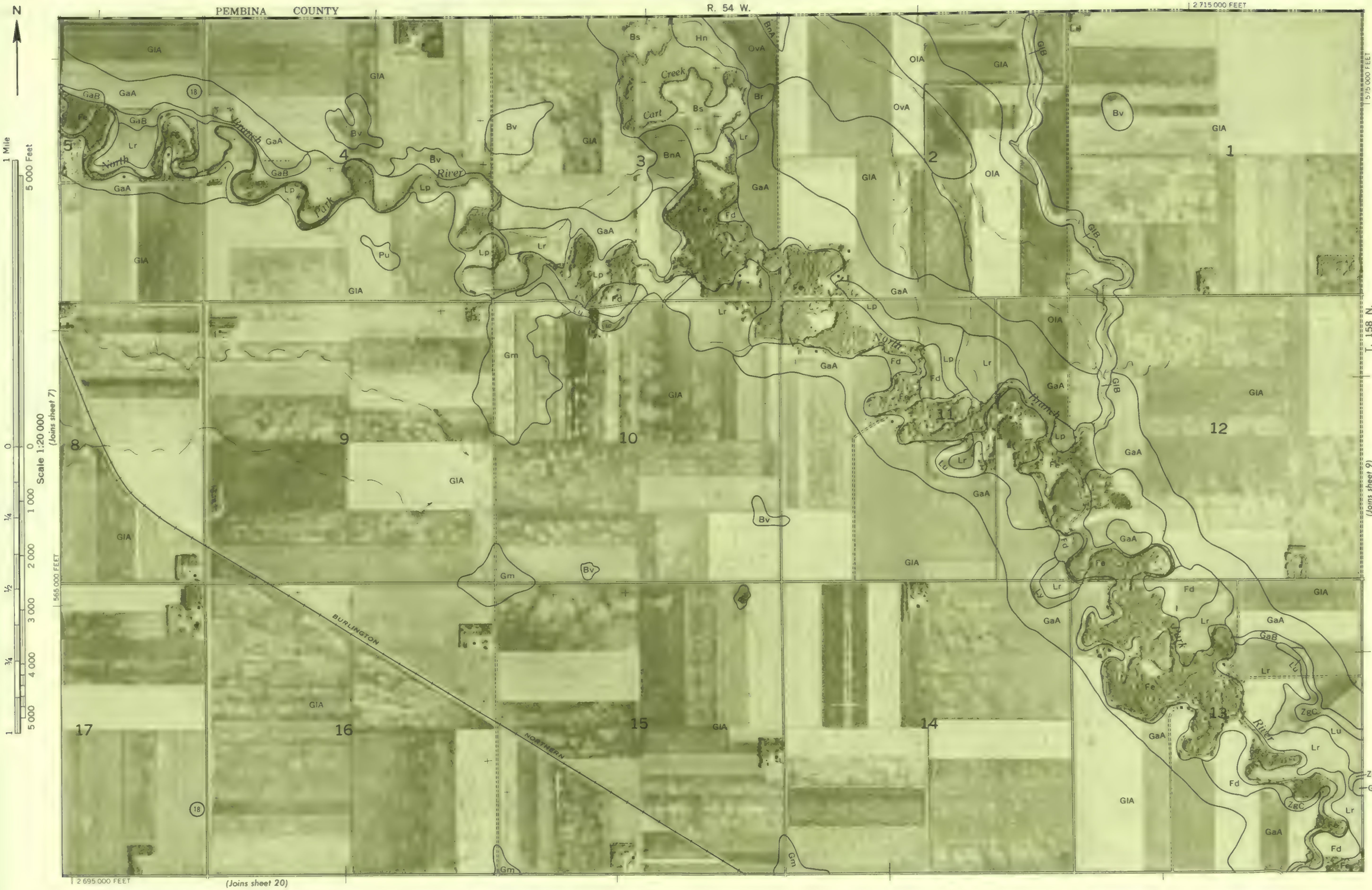
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 7

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 8



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This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

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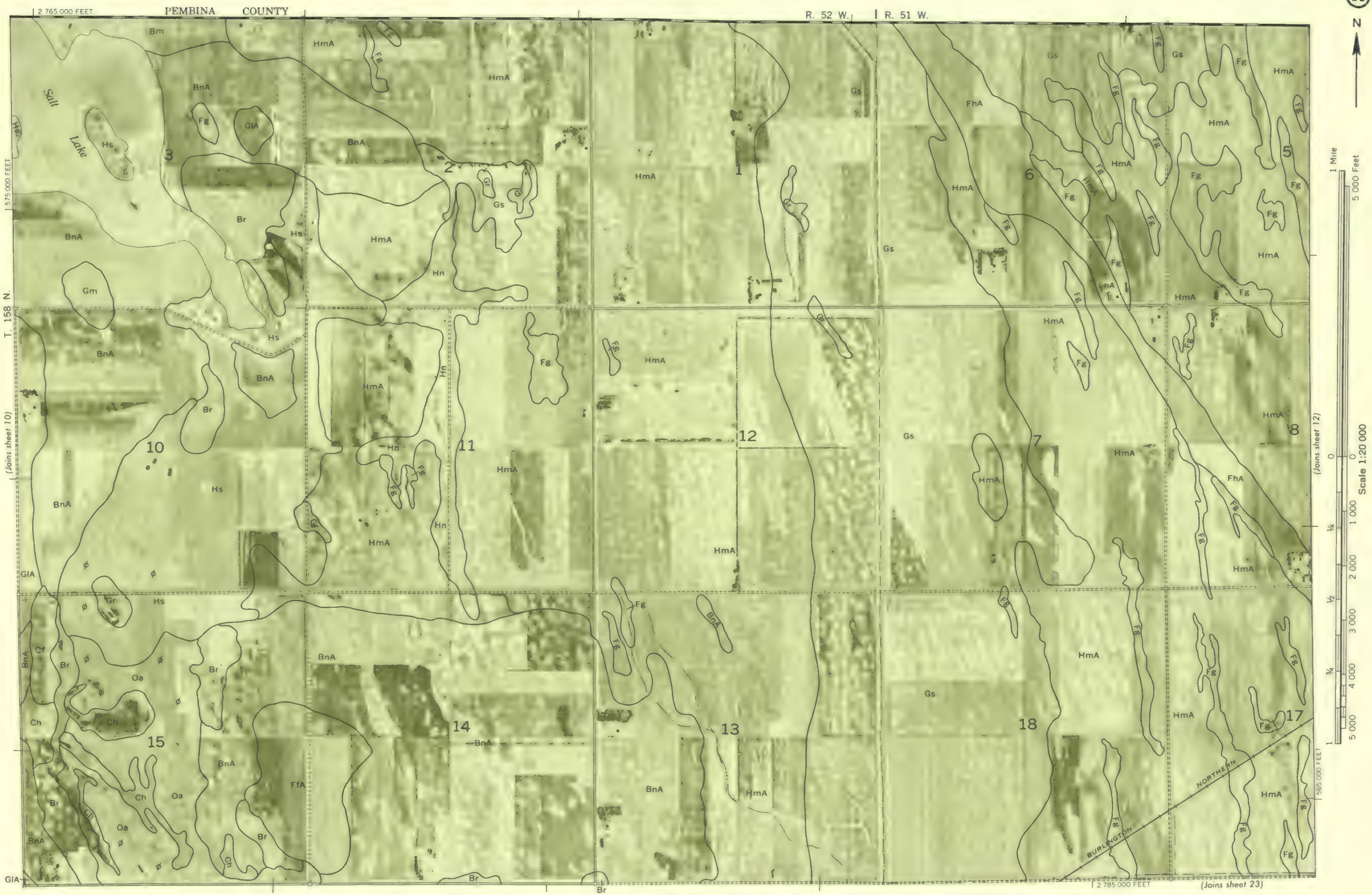
WALSH COUNTY, NORTH DAKOTA NO. 9

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 10

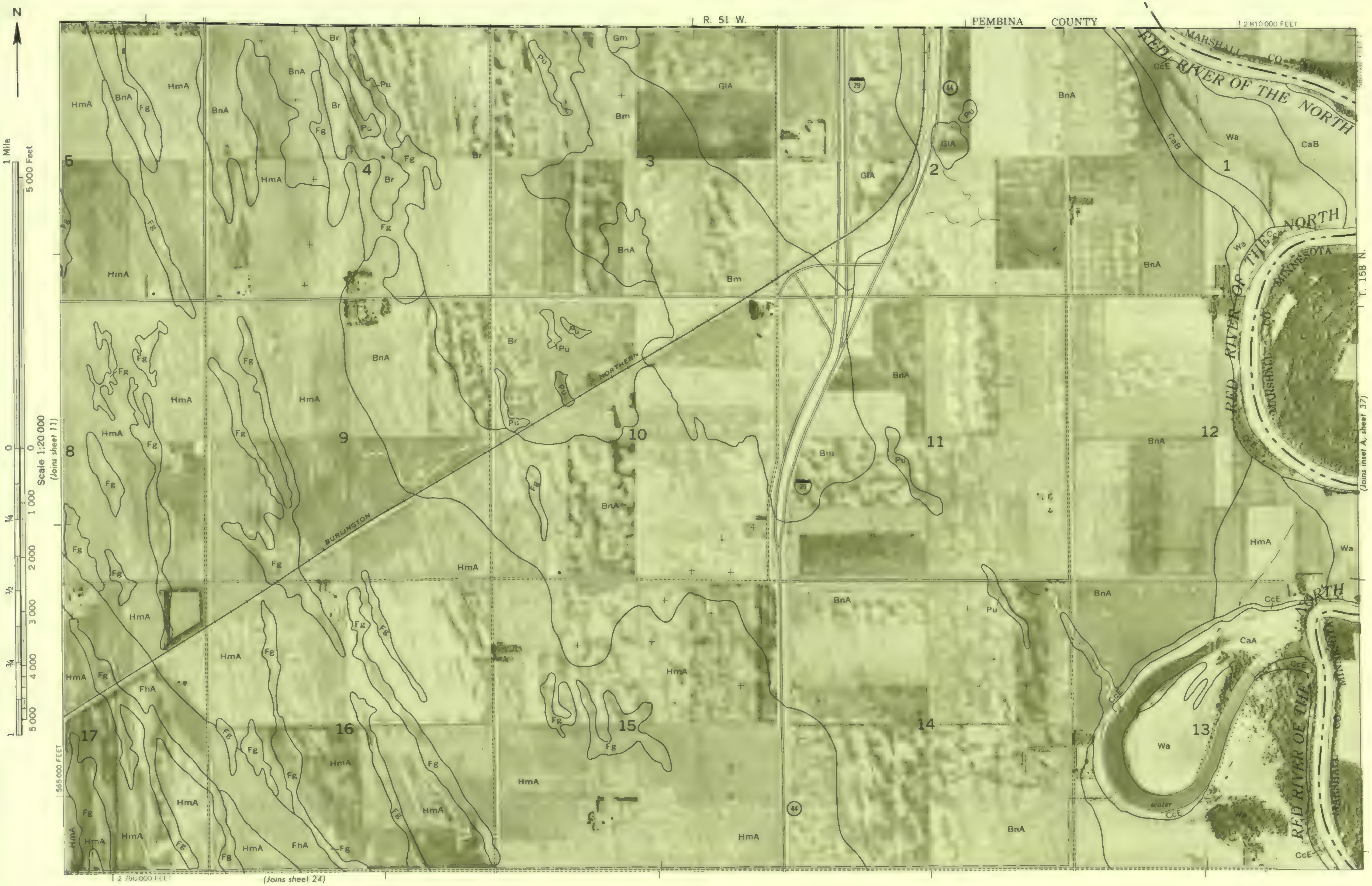
WALSH COUNTY, NORTH DAKOTA NO. 10

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.



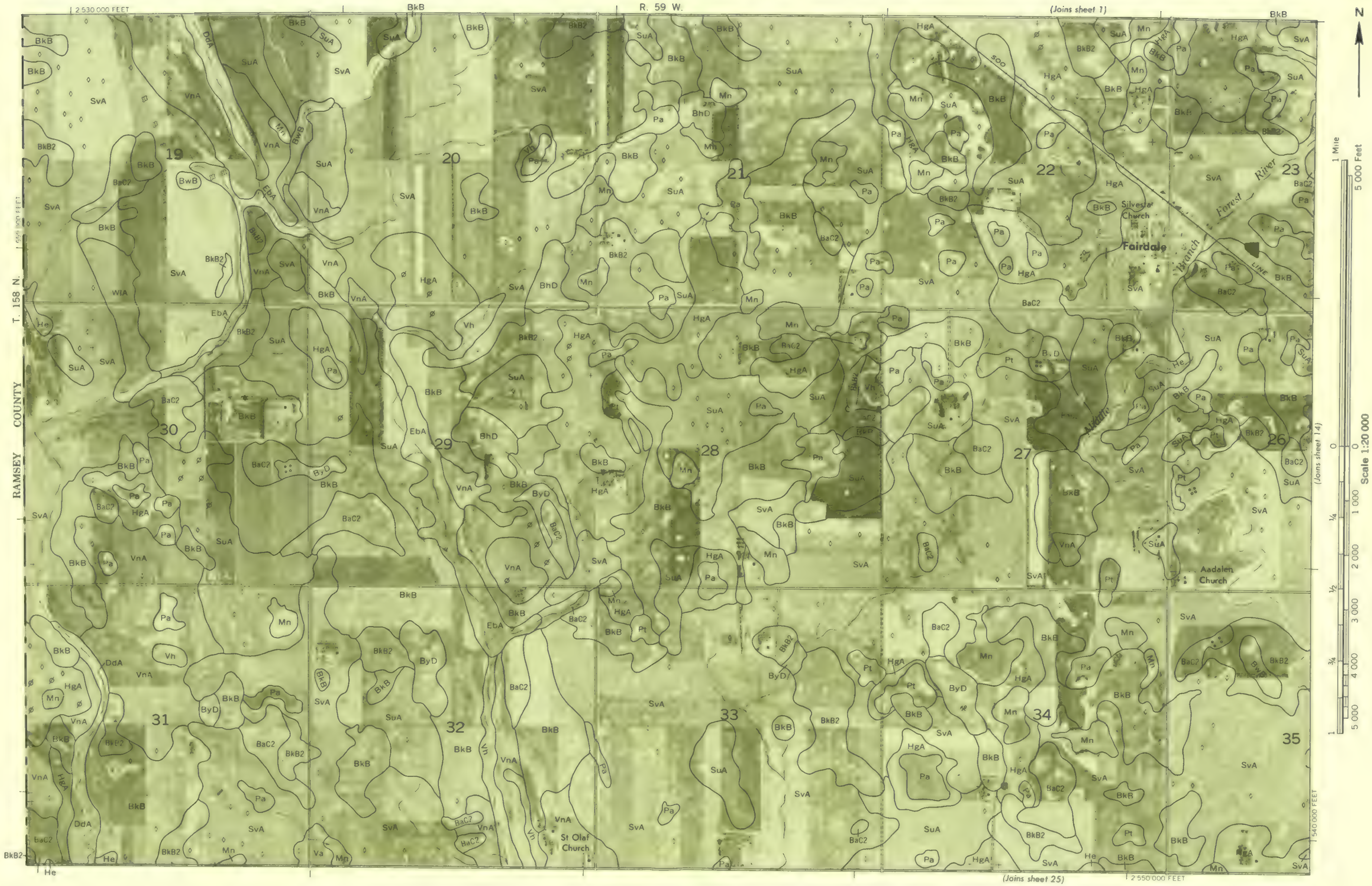
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum
Land division corners are approximately positioned on this map.
WALSH COUNTY, NORTH DAKOTA NO. 11

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 12



WALSH COUNTY, NORTH DAKOTA NO. 12

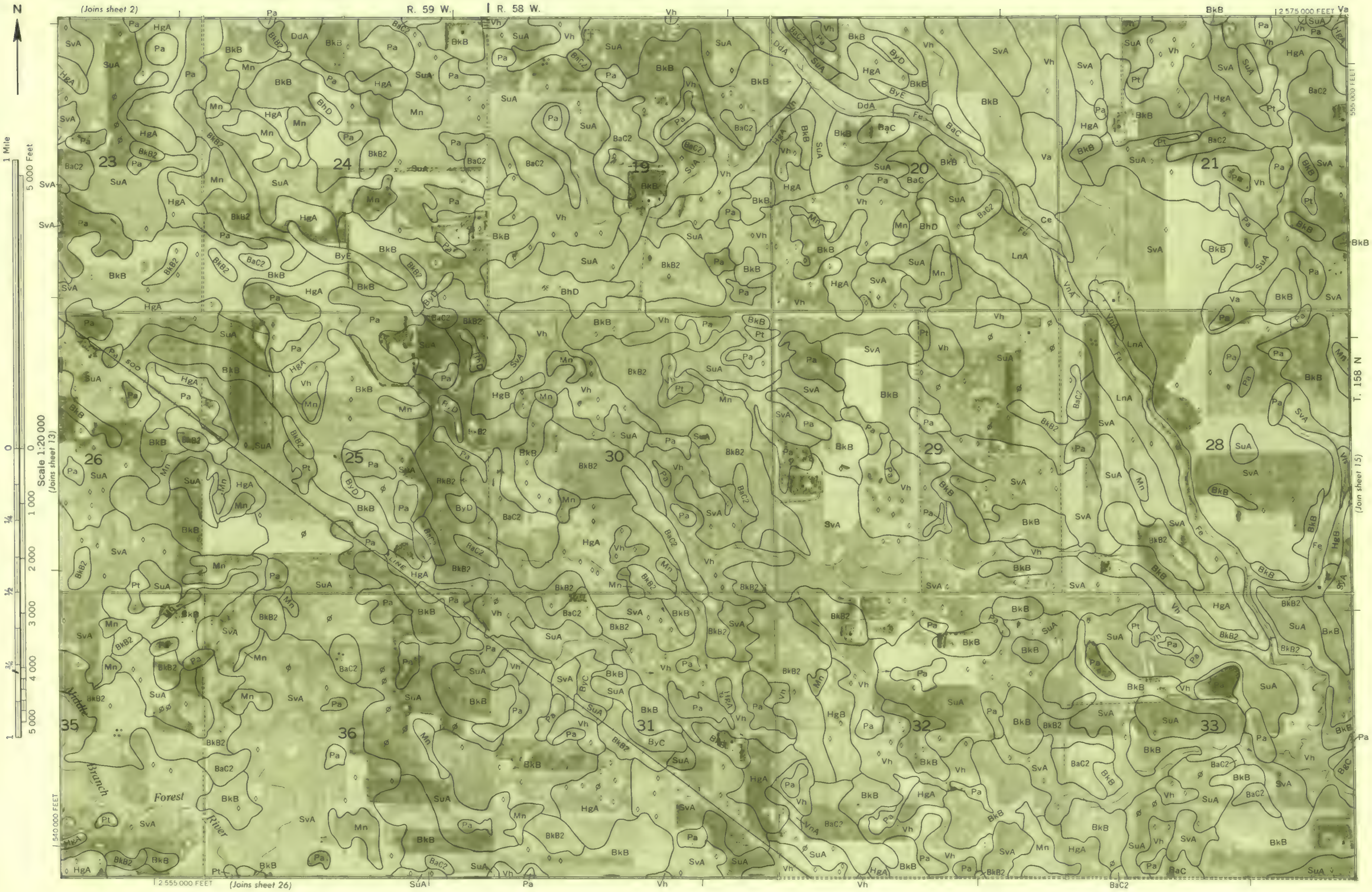
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 13

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 14



WALSH COUNTY, NORTH DAKOTA NO. 14

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

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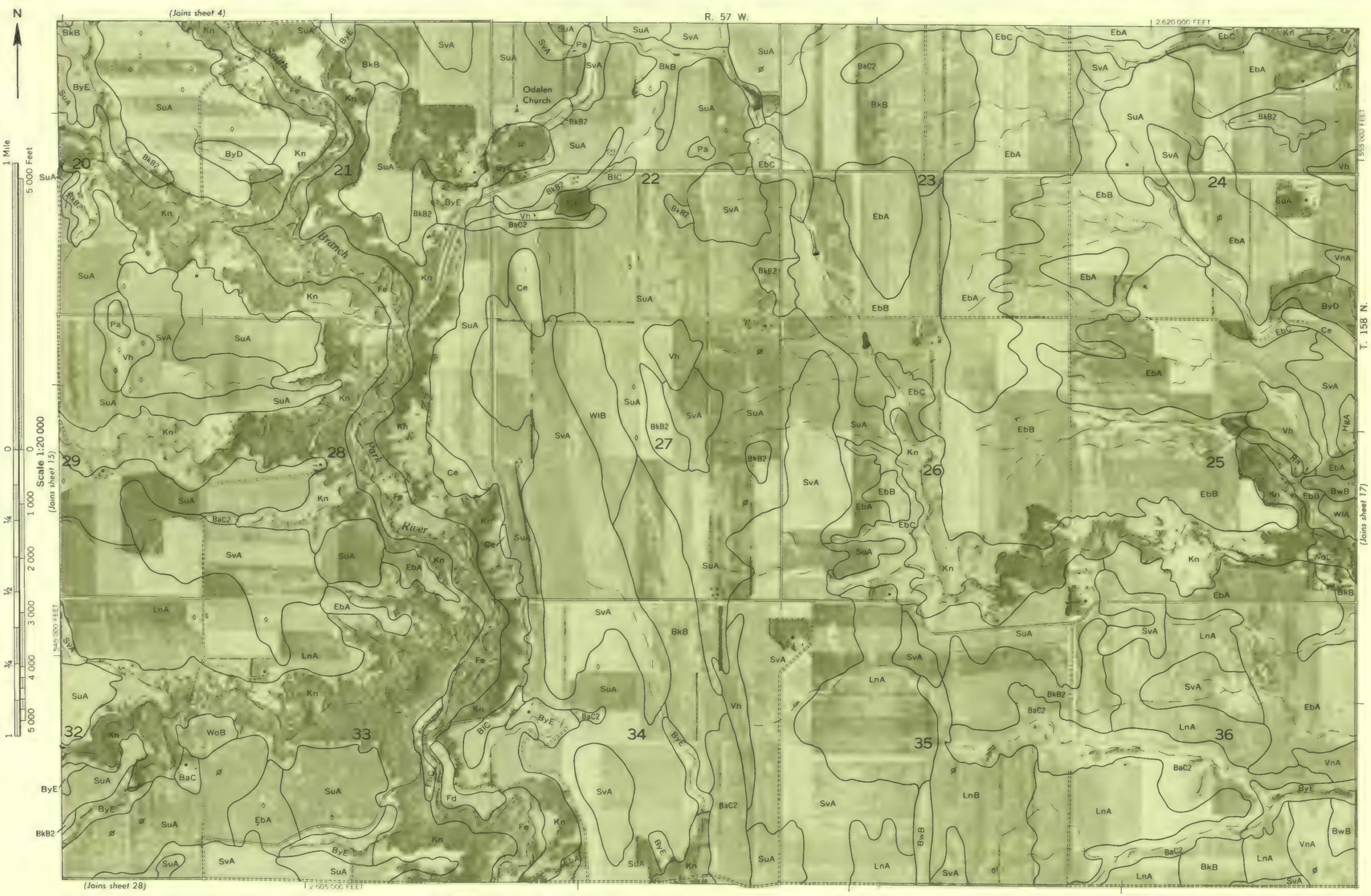
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 15

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 16



WALSH COUNTY, NORTH DAKOTA NO. 16

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

17

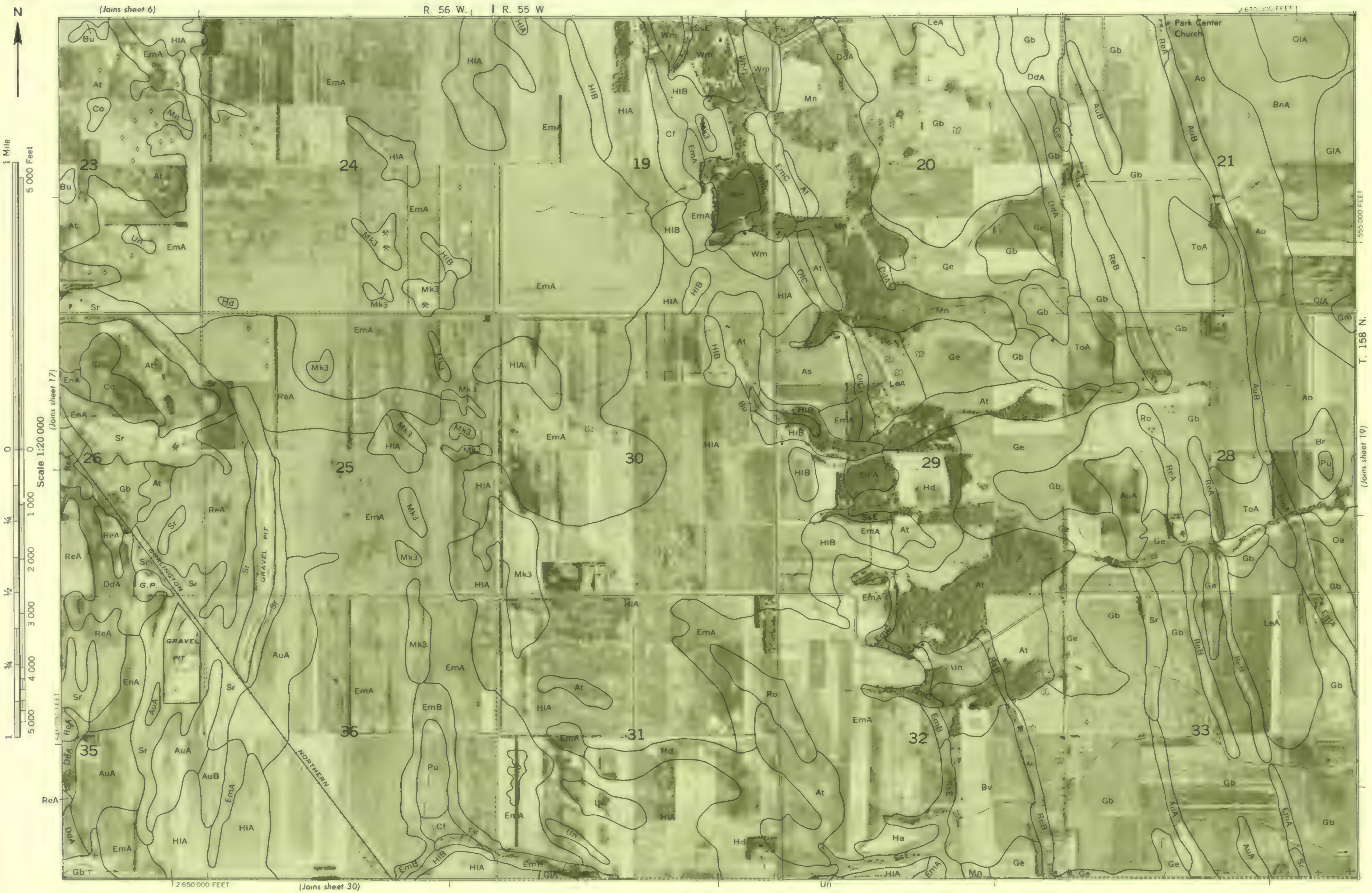
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

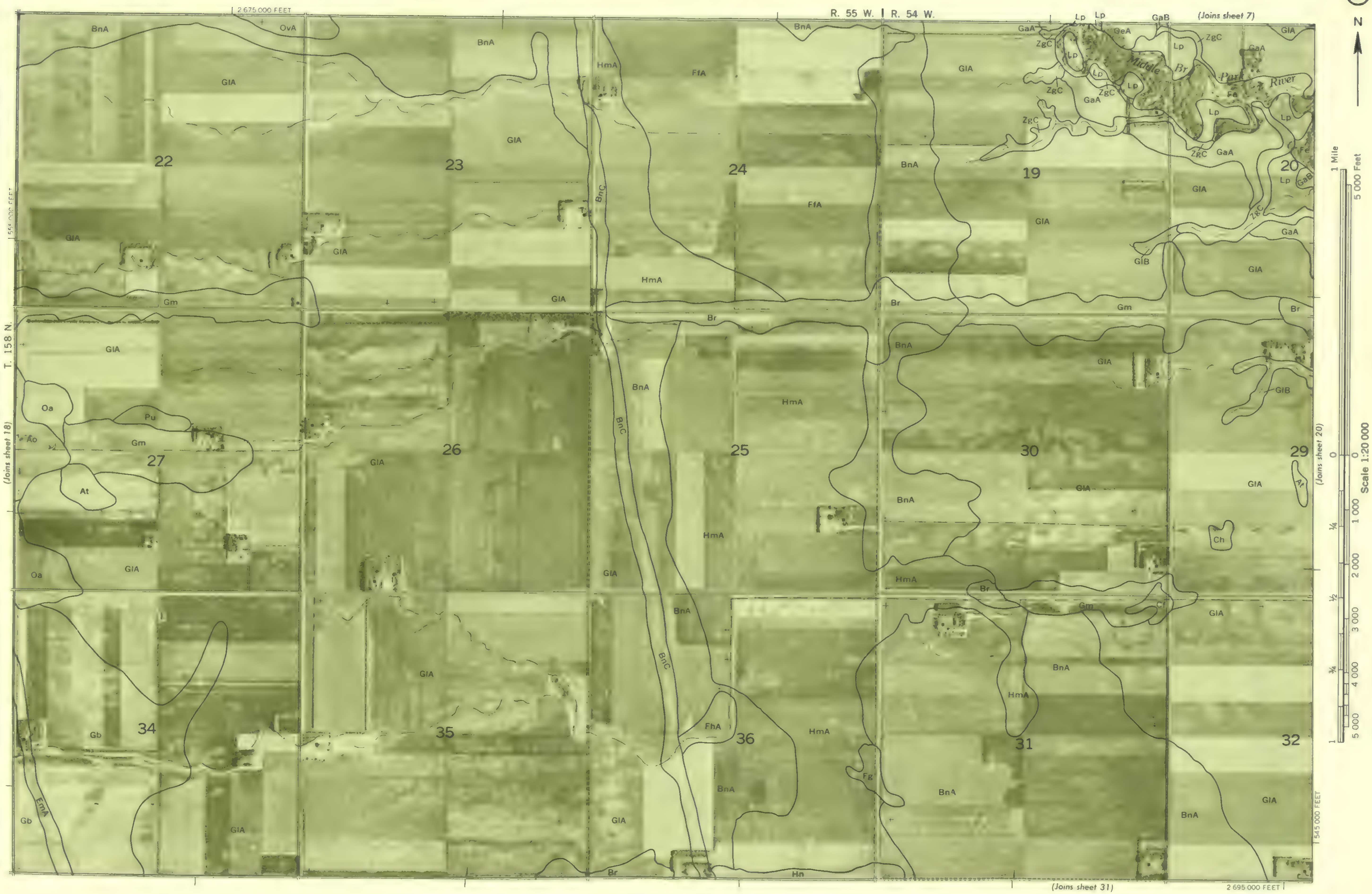
WALSH COUNTY, NORTH DAKOTA NO. 17

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 18



WALSH COUNTY, NORTH DAKOTA NO. 18

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photography. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.
WALSH COUNTY, NORTH DAKOTA NO. 19

WALSH COUNTY, NORTH DAKOTA NO. 20

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

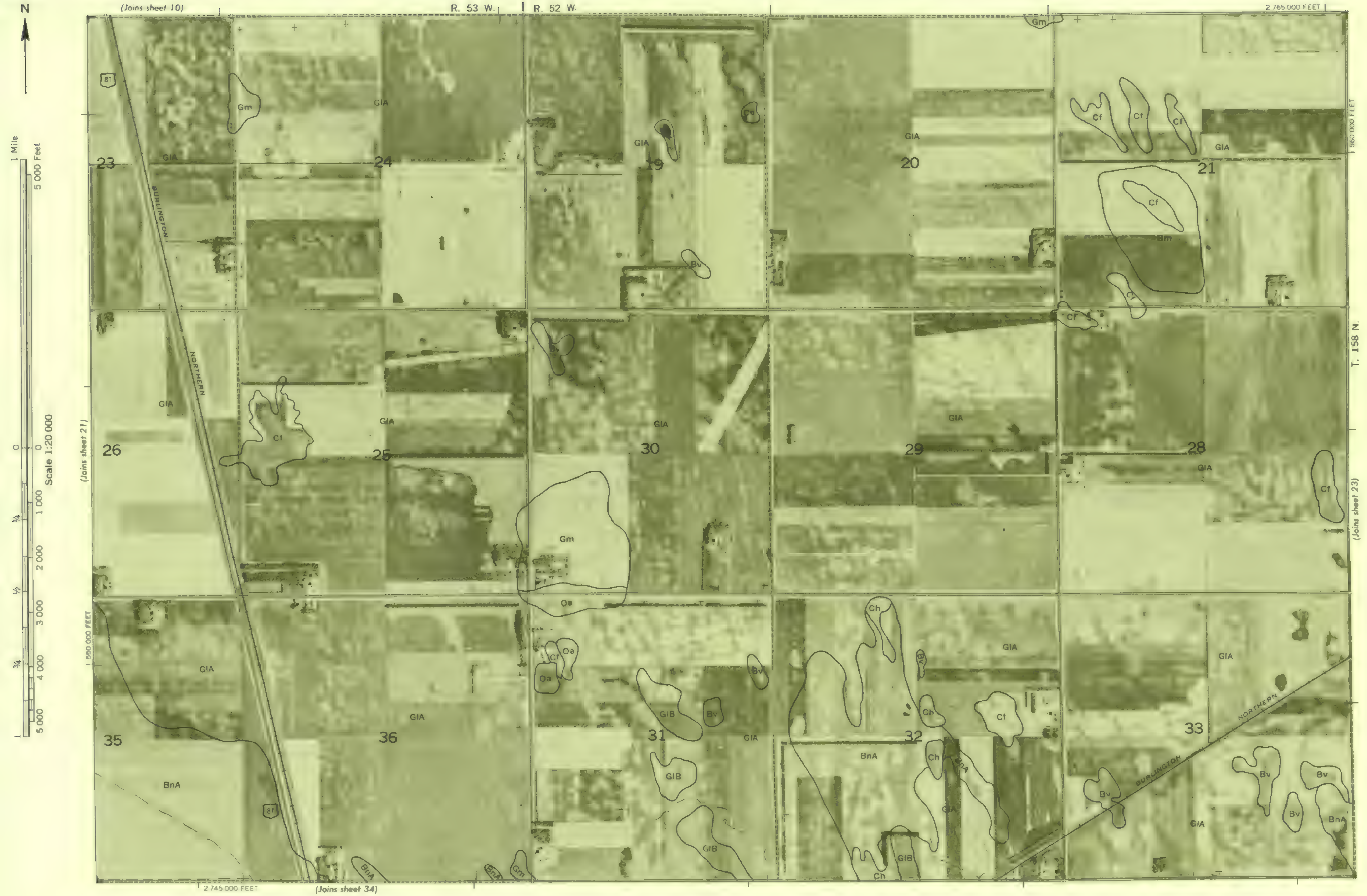
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 21

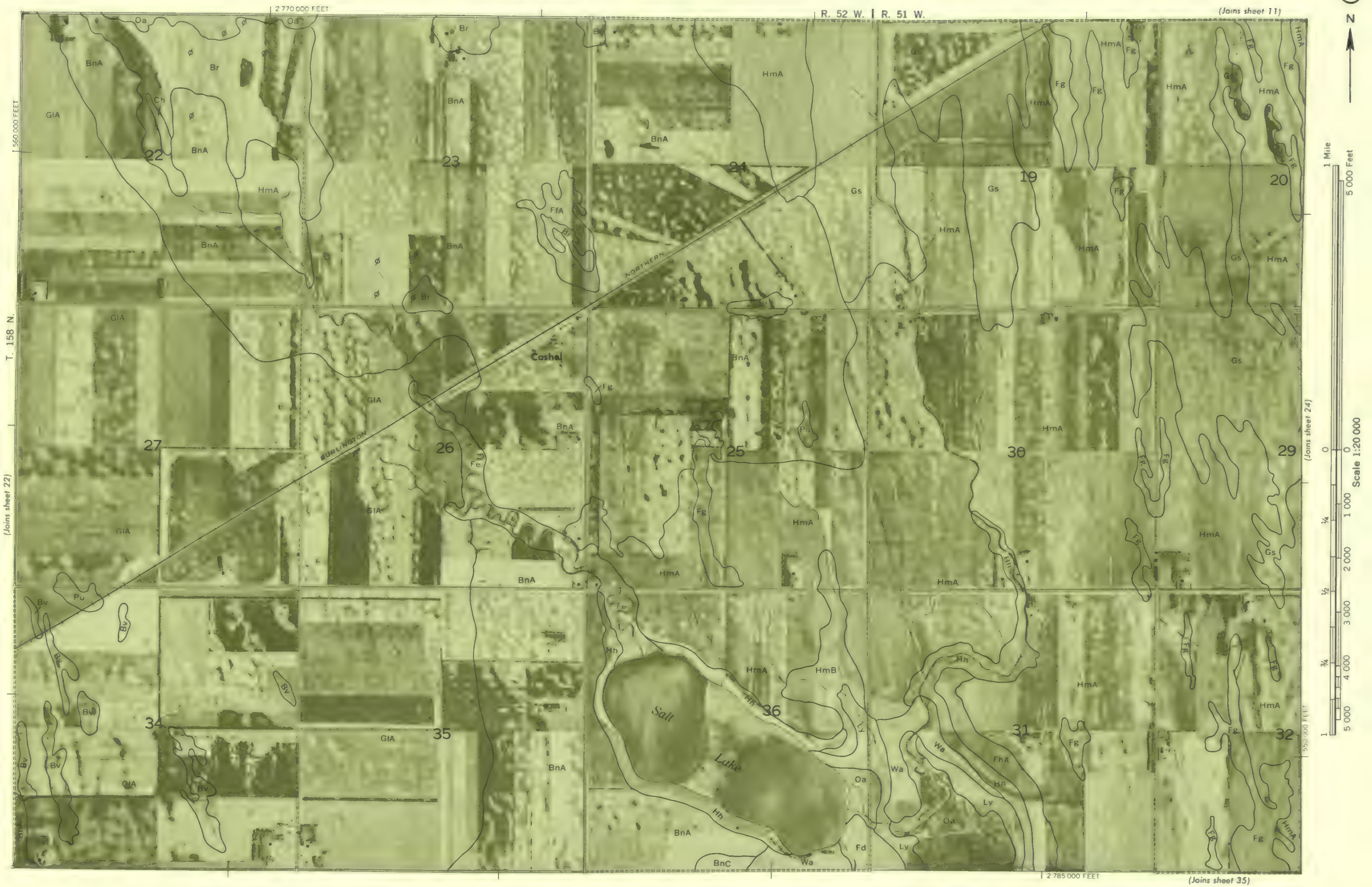
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.
WALSH COUNTY, NORTH DAKOTA NO. 21

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 22



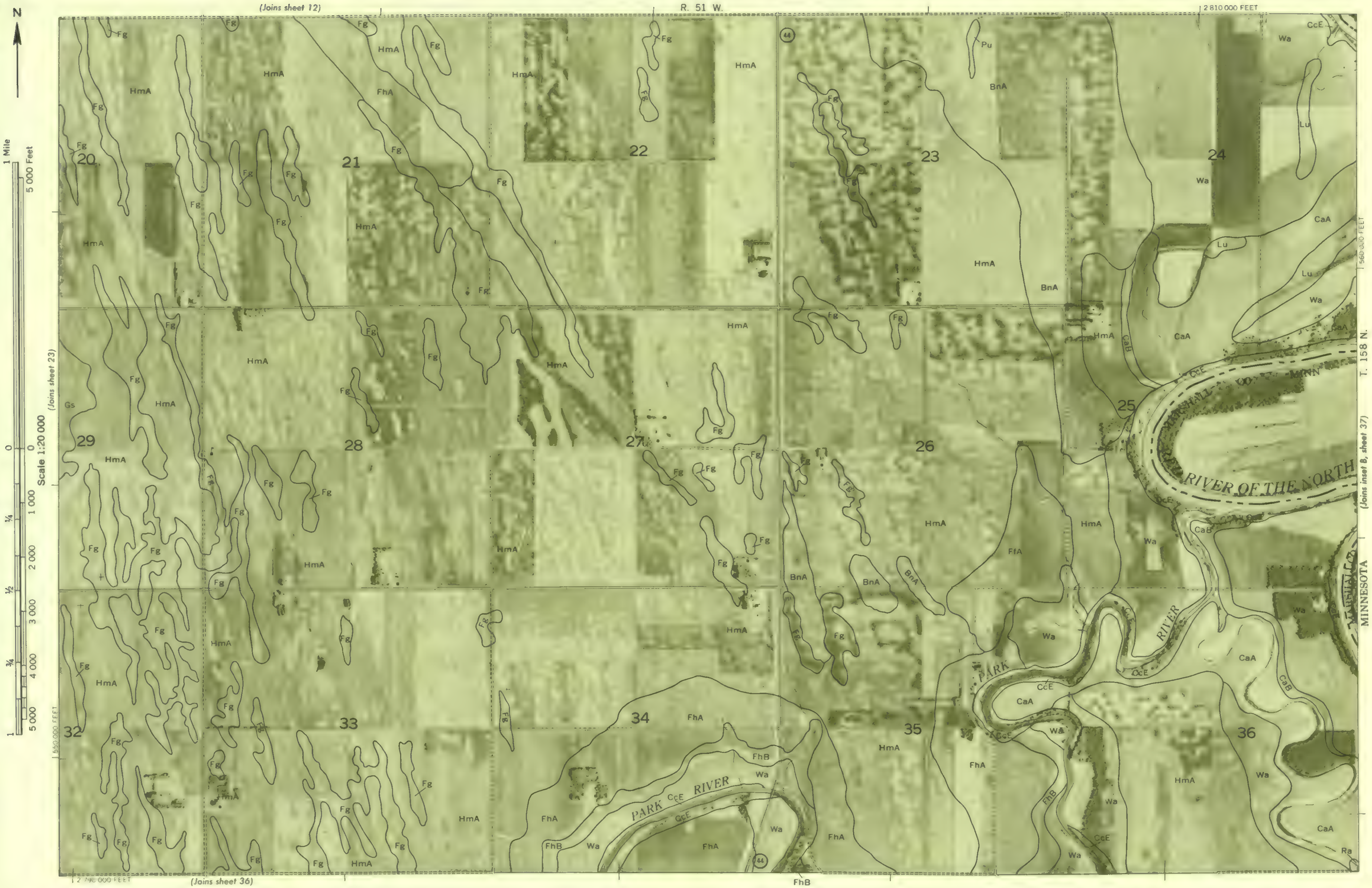
WALSH COUNTY, NORTH DAKOTA NO. 22

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 23



WALSH COUNTY, NORTH DAKOTA NO. 24

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

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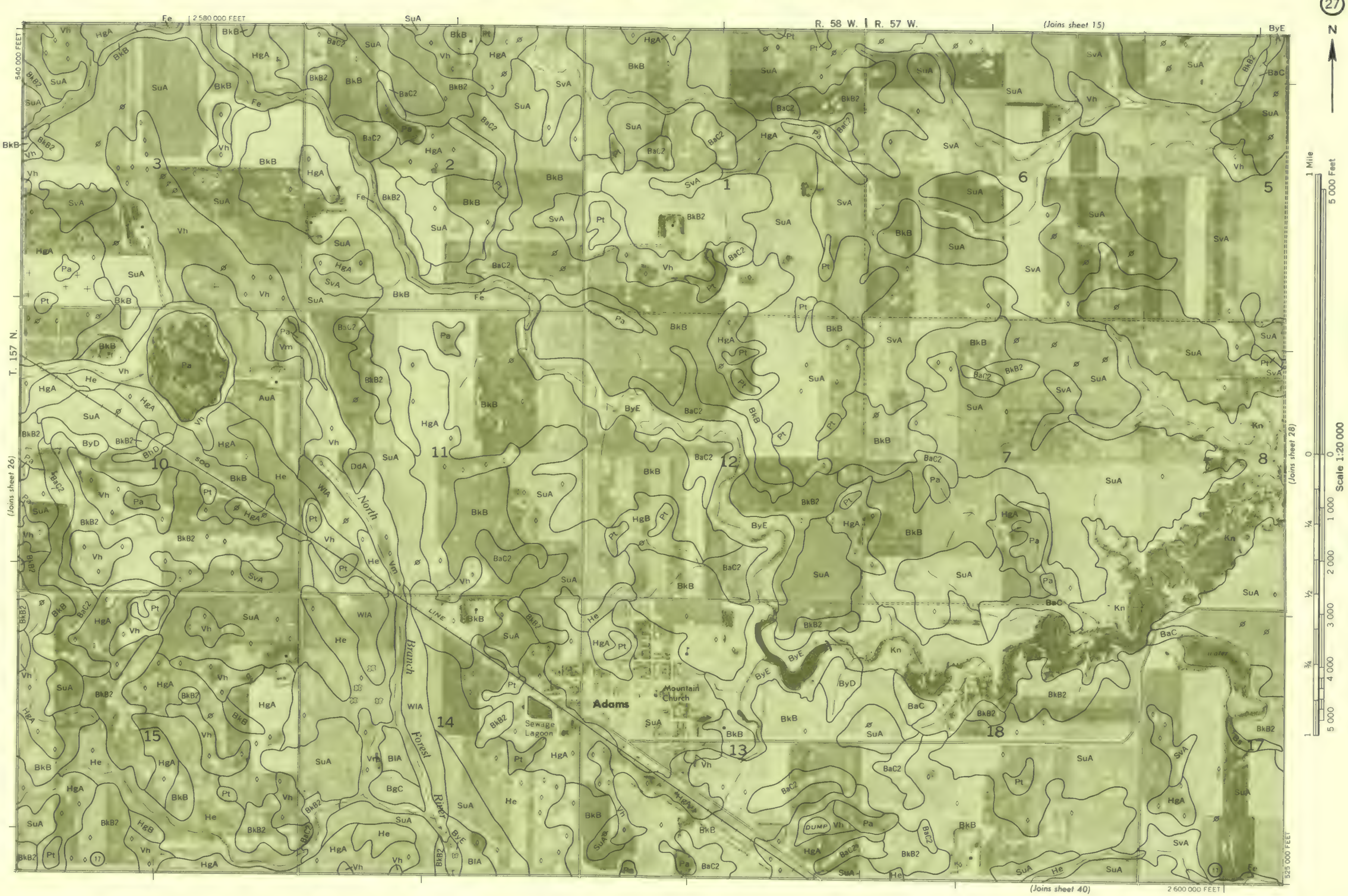
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 25

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 26

WALSH COUNTY, NORTH DAKOTA NO. 26

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

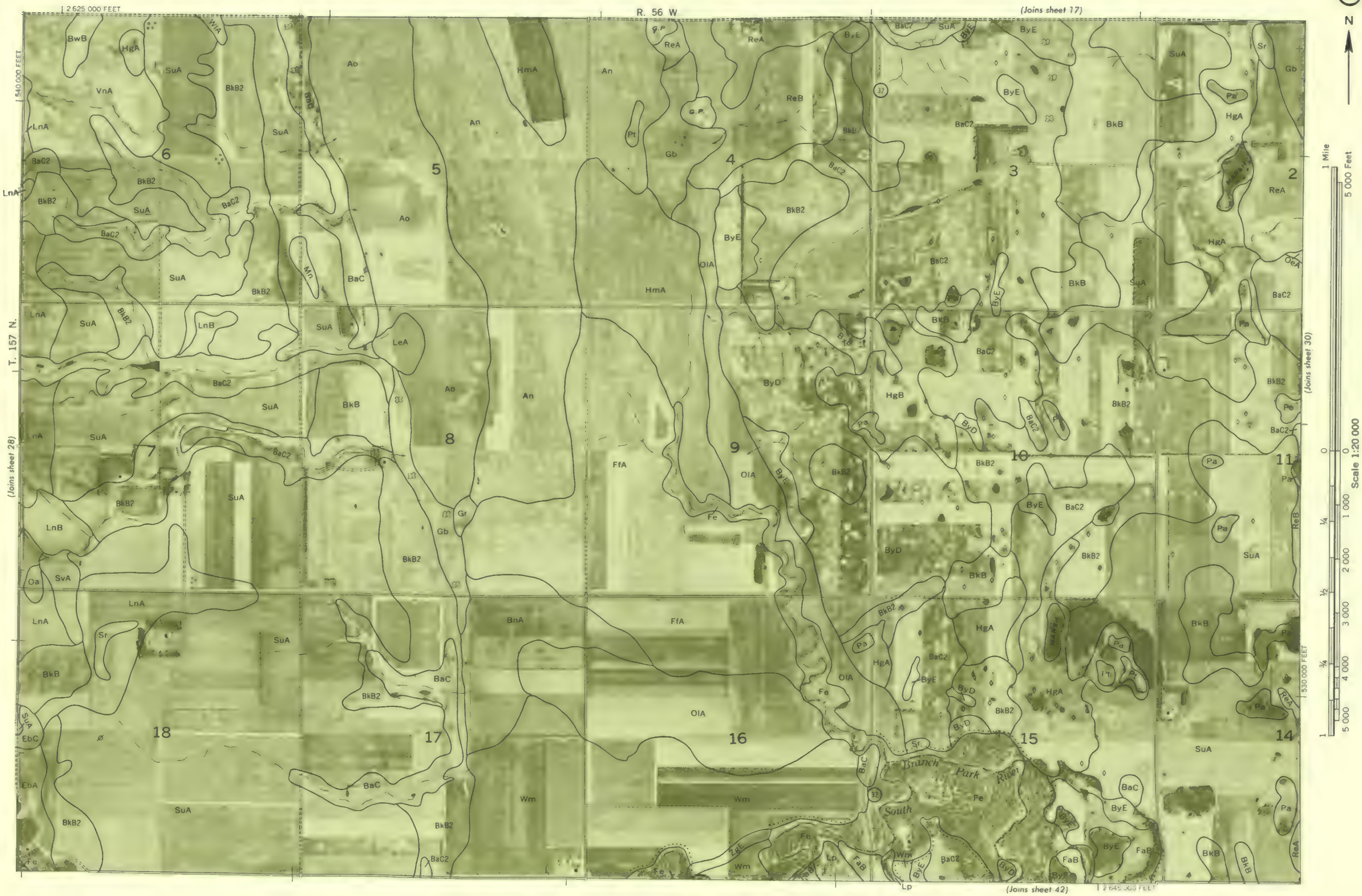


This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 27

WALSH COUNTY, NORTH DAKOTA NO. 28

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

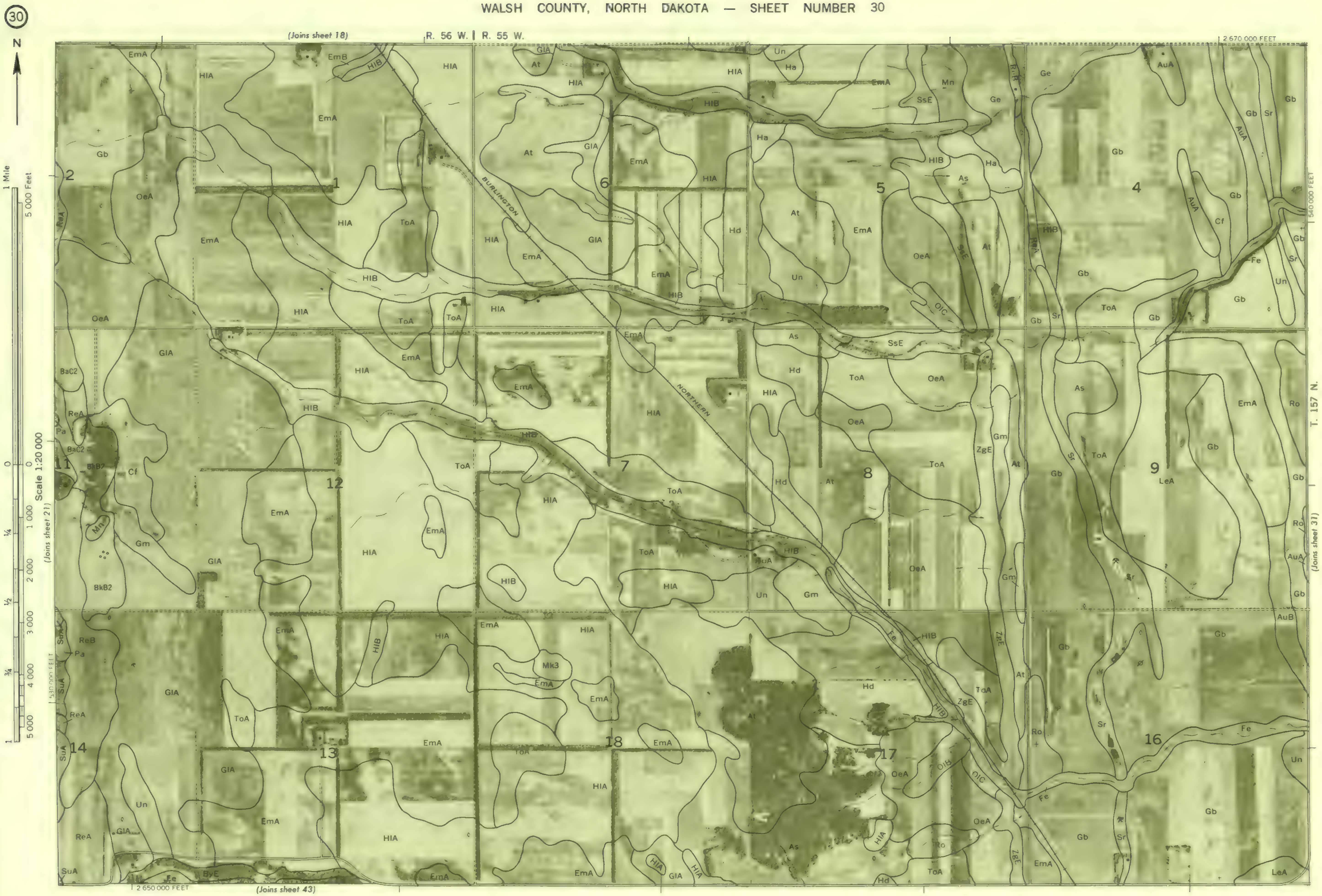


WALSH COUNTY, NORTH DAKOTA NO. 29

Land division corners are approximately positioned on this map.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.



WALSH COUNTY, NORTH DAKOTA NO. 30

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

Land division corners are approximately positioned on this map.

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Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 31

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 32

WALSH COUNTY, NORTH DAKOTA NO. 32

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

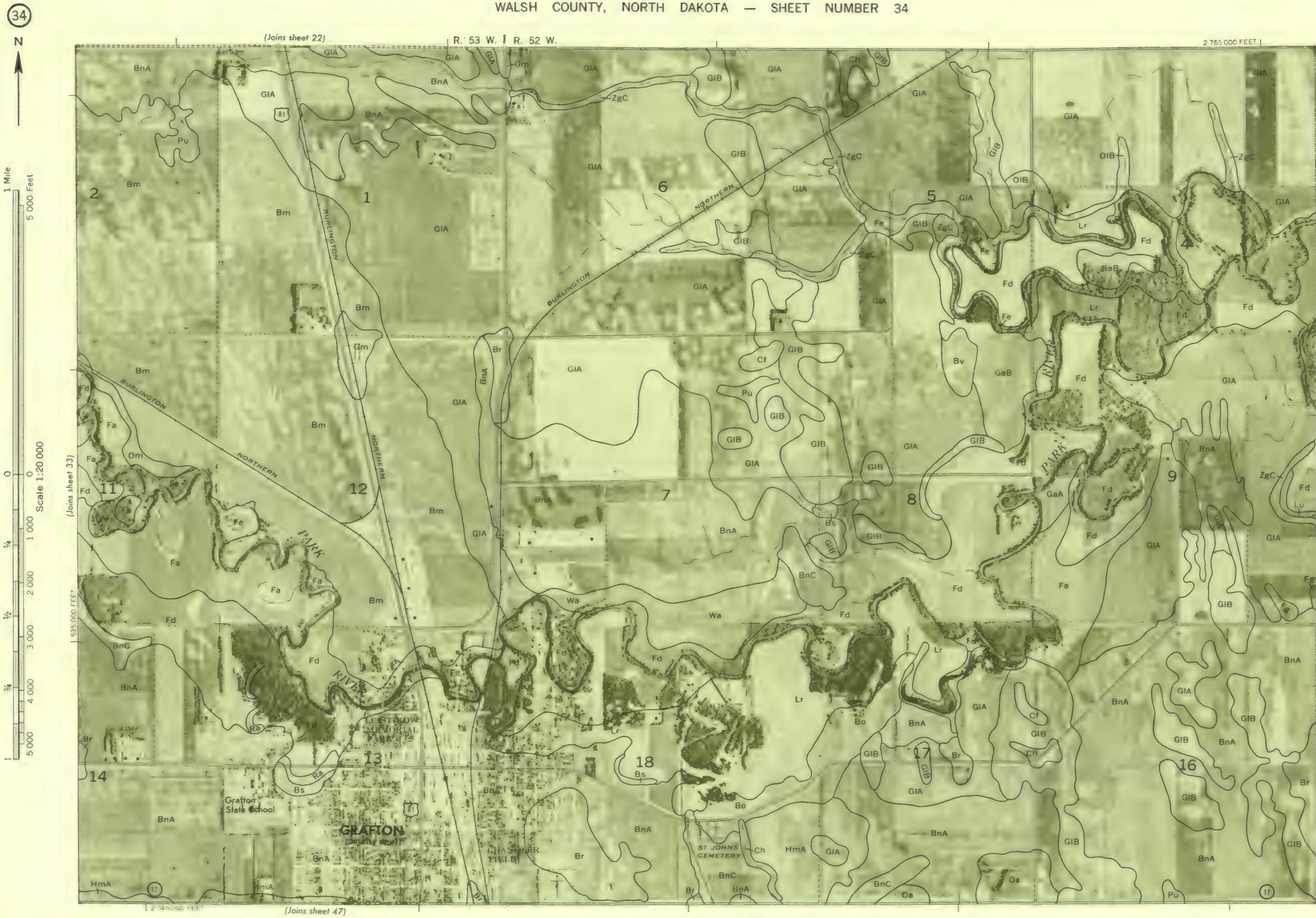
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

33

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 33



WALSH COUNTY, NORTH DAKOTA NO. 34

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

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Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 35

WALSH COUNTY, NORTH DAKOTA NO. 36

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

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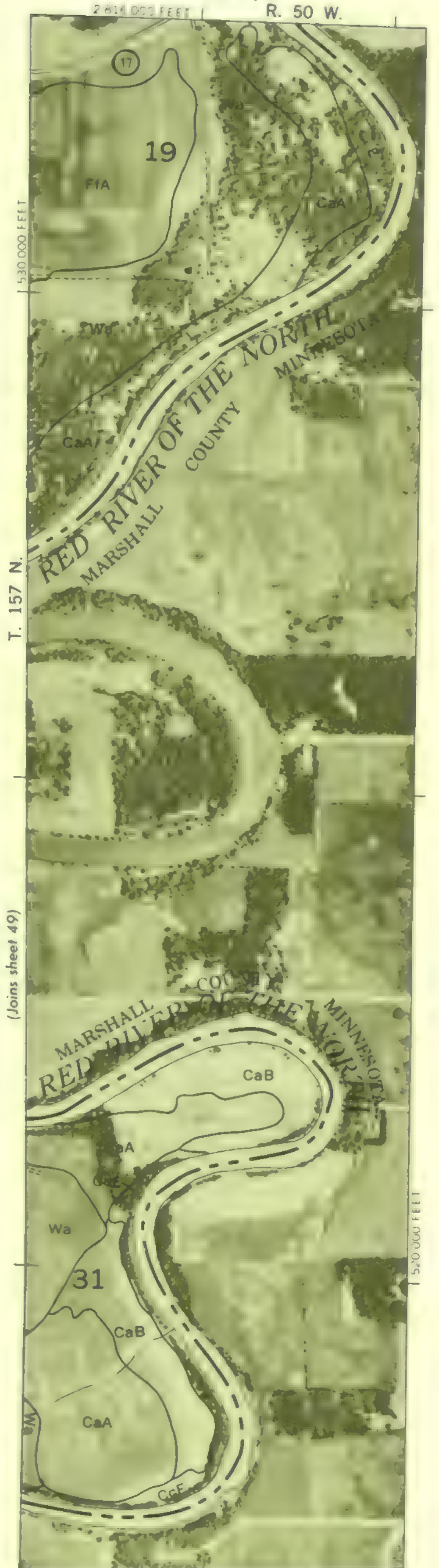
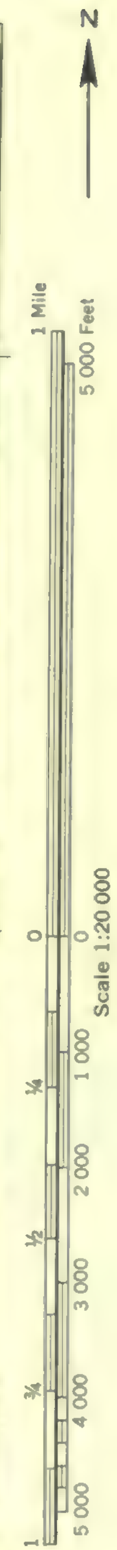
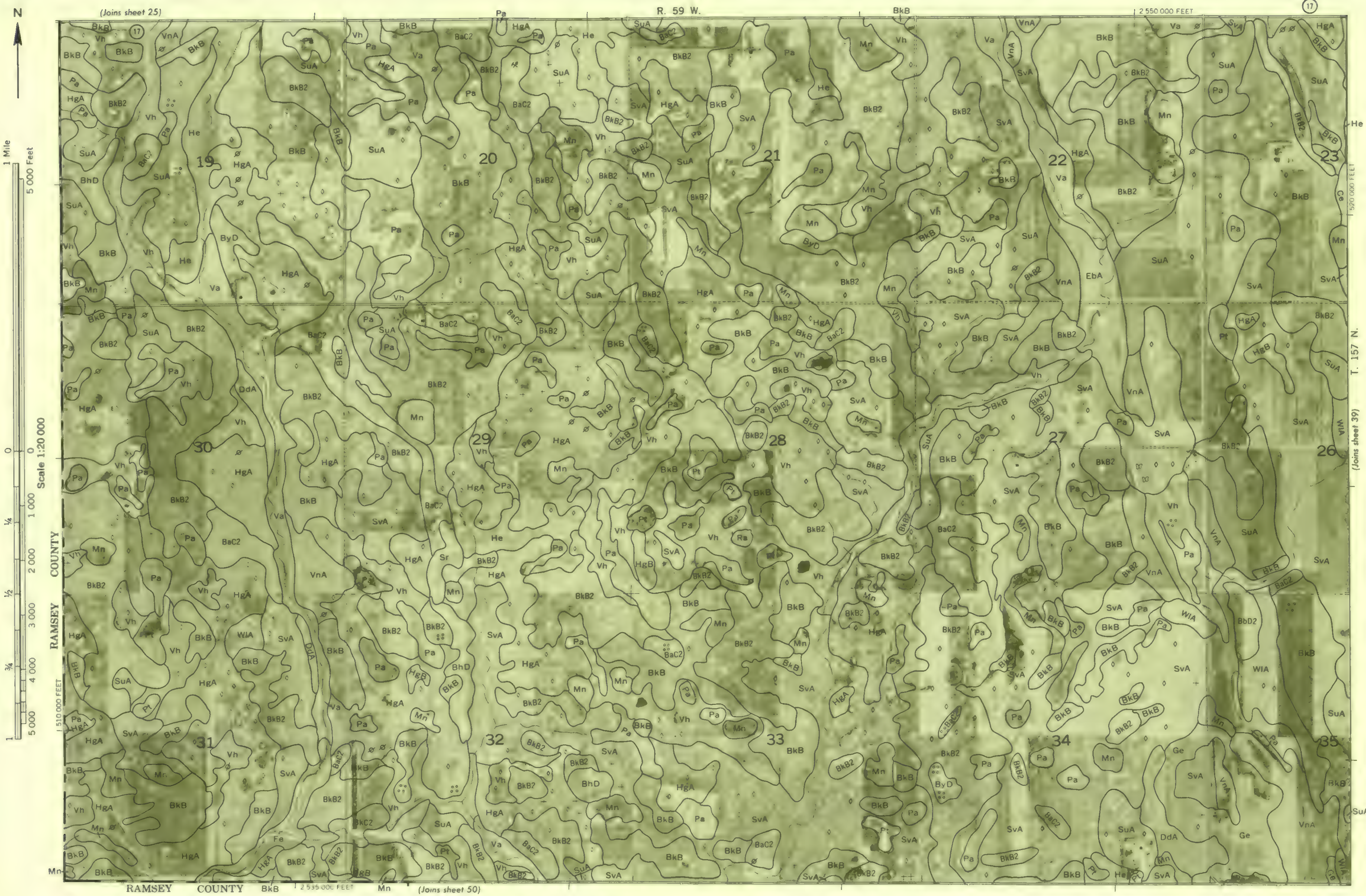
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.
WALSH COUNTY, NORTH DAKOTA NO. 37





WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 38



WALSH COUNTY, NORTH DAKOTA NO. 38

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
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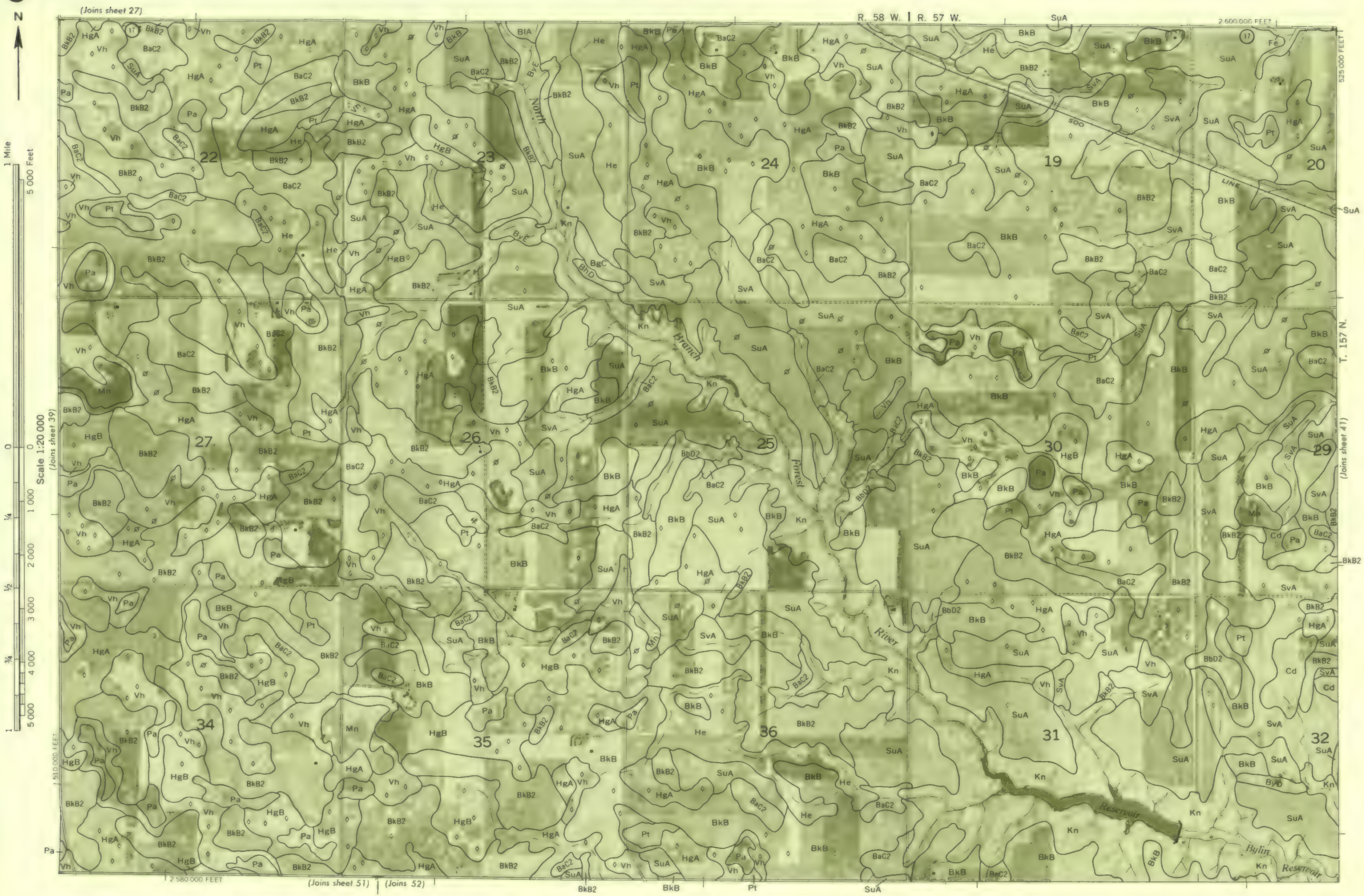
Land division corners are approximately positioned on this map.

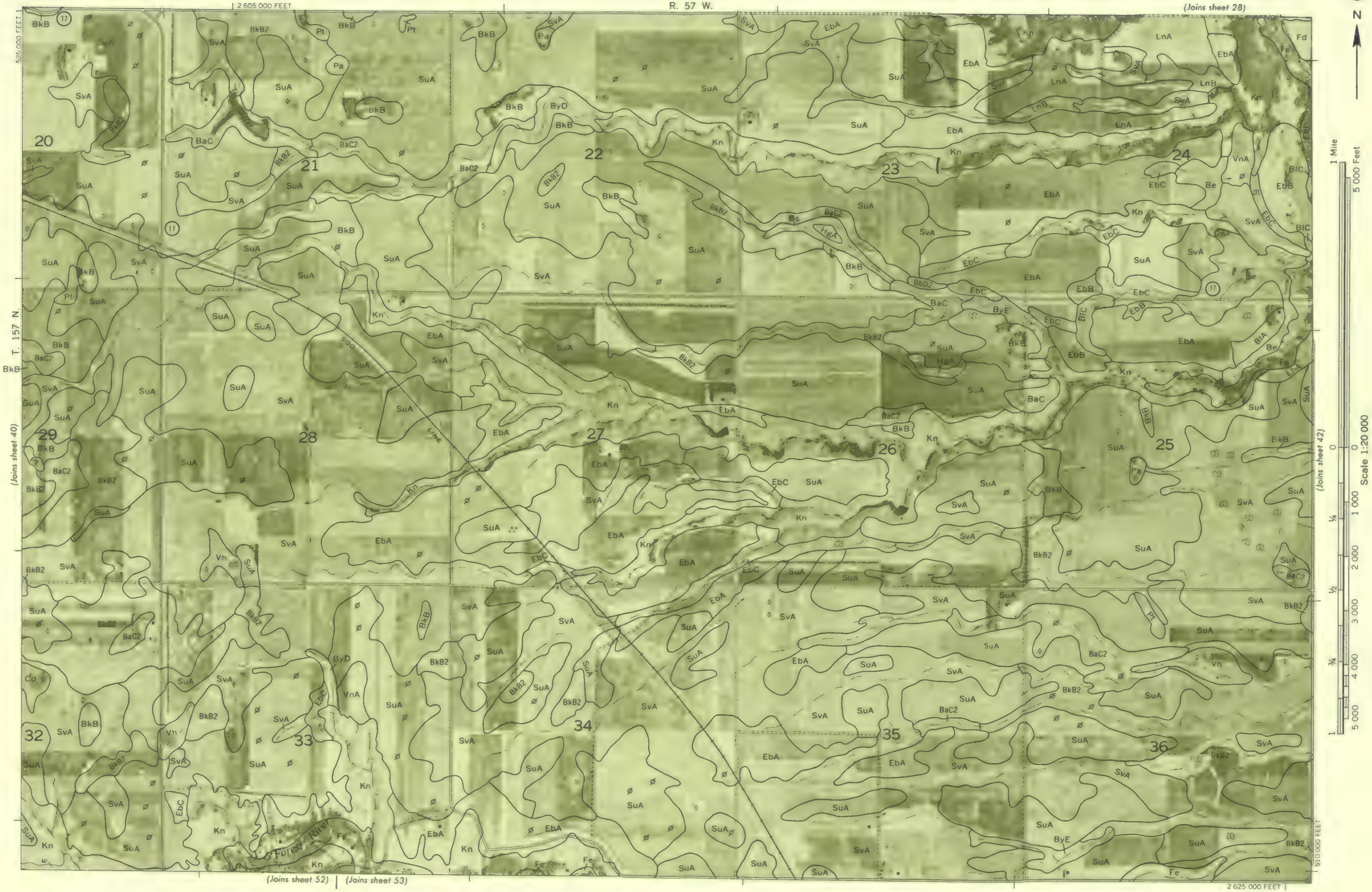
WALSH COUNTY, NORTH DAKOTA NO. 39

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 40



WALSH COUNTY, NORTH DAKOTA NO. 40

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.



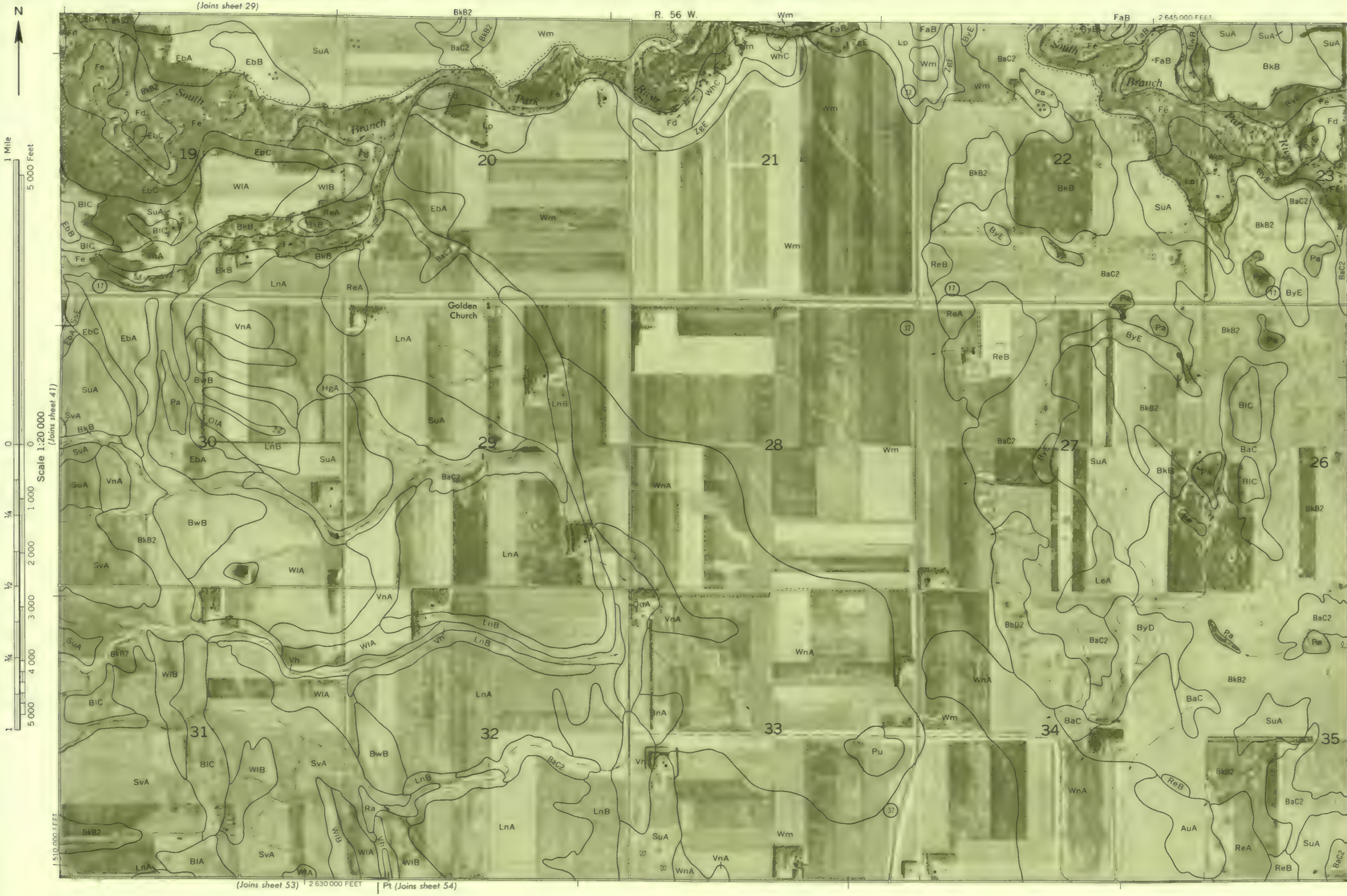
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 41

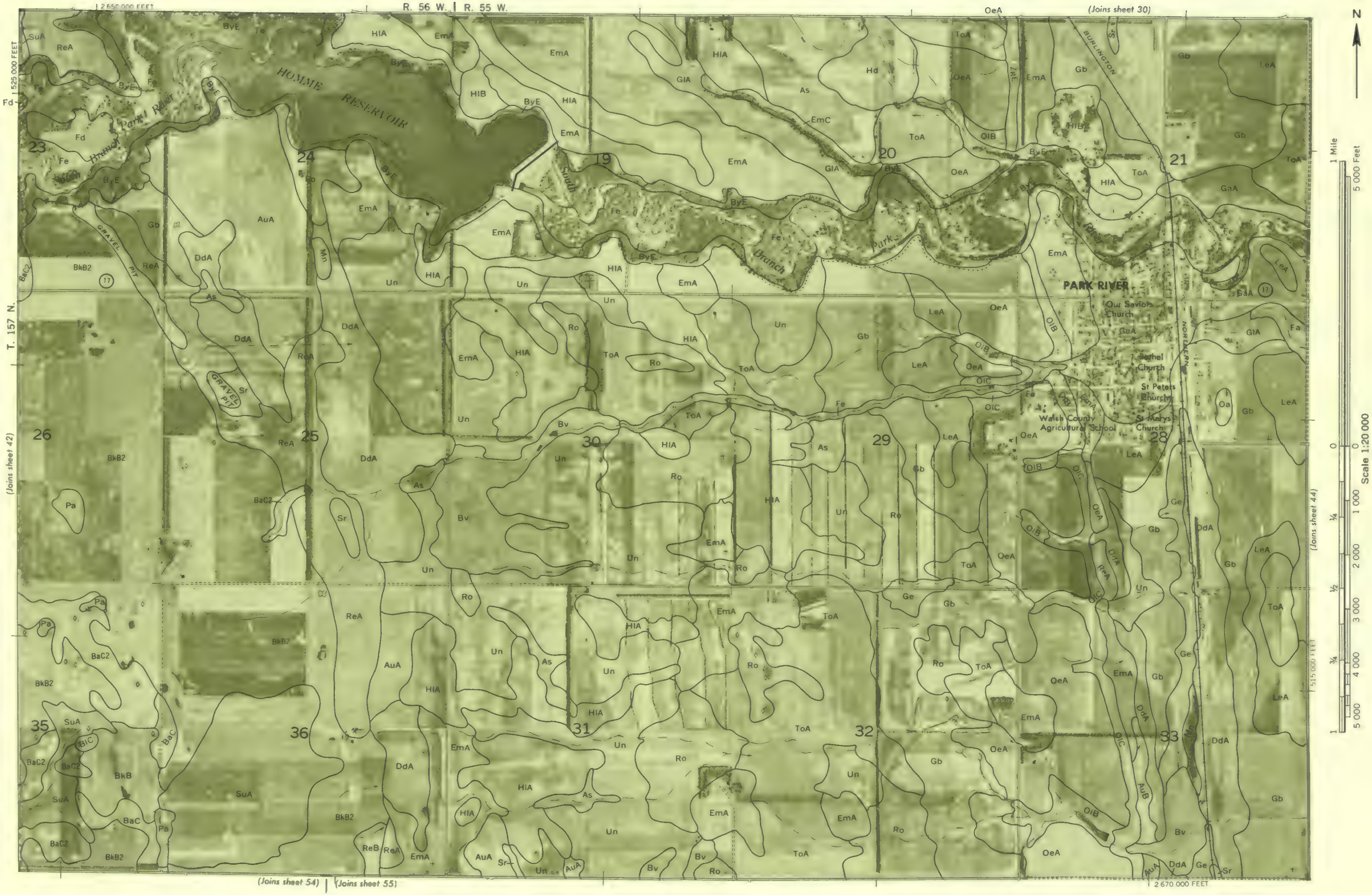
WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 42



WALSH COUNTY, NORTH DAKOTA NO. 42

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.



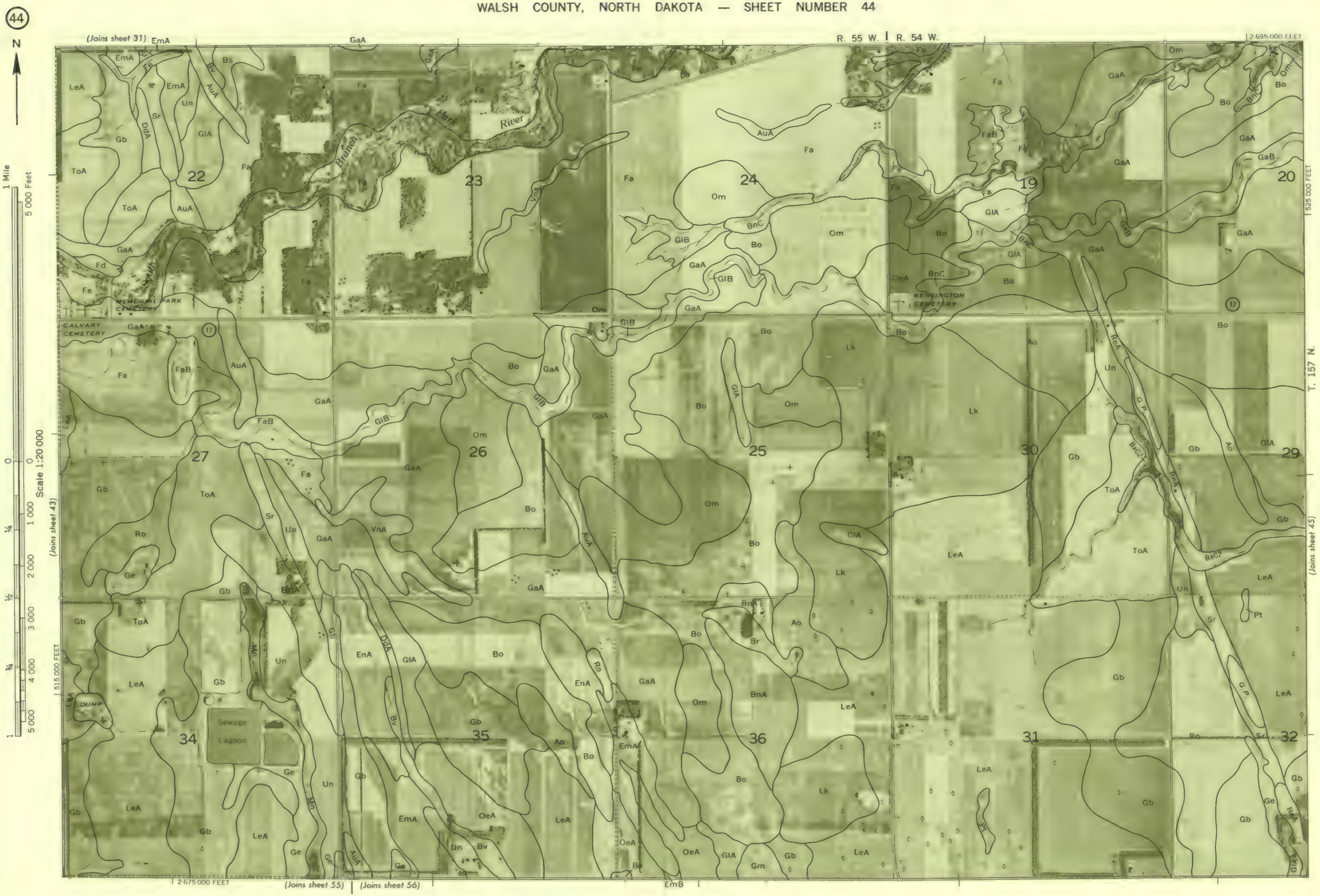
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 43

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 44



WALSH COUNTY, NORTH DAKOTA NO. 44

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

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Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

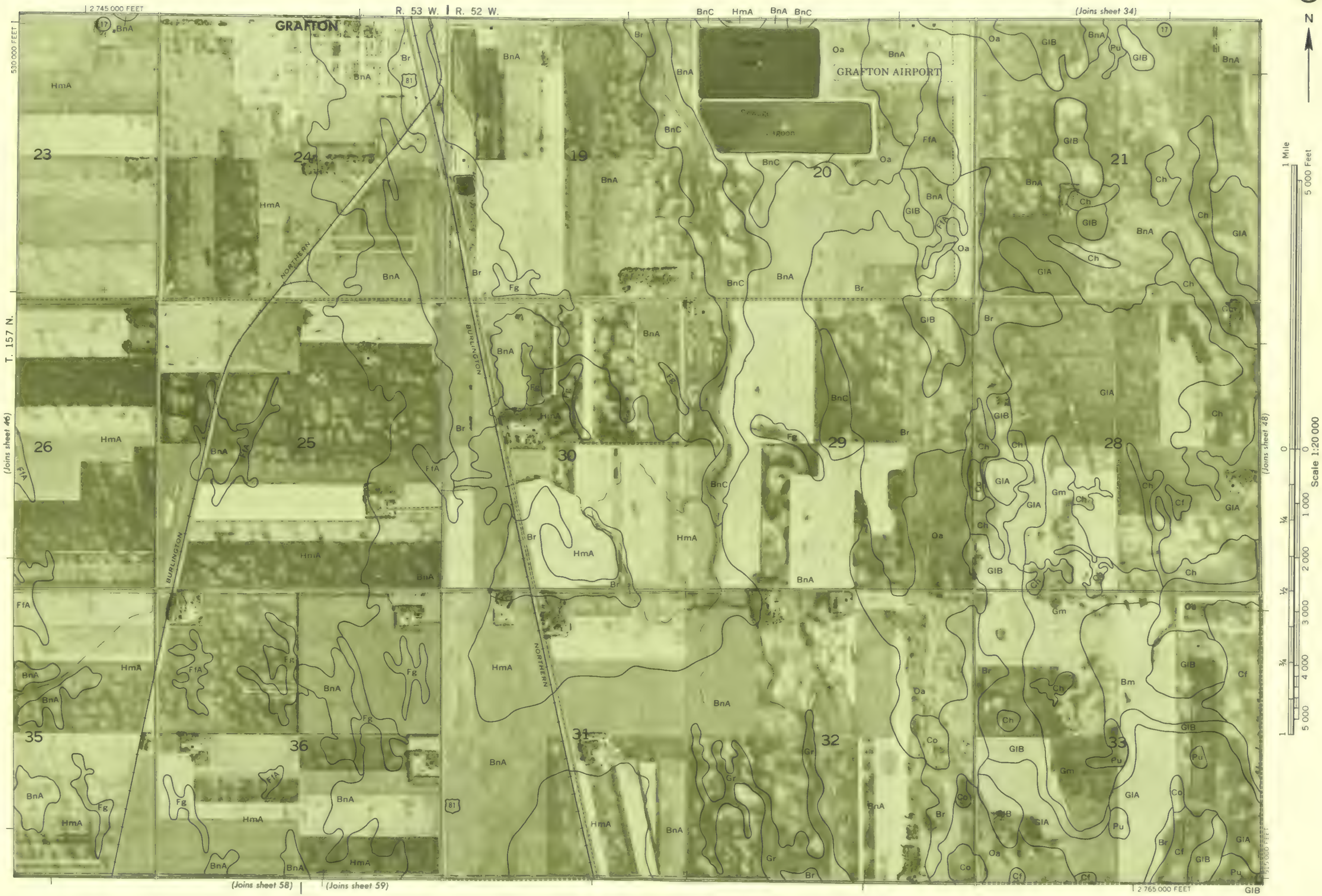
WALSH COUNTY, NORTH DAKOTA NO. 45

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 46

WALSH COUNTY, NORTH DAKOTA NO. 46

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

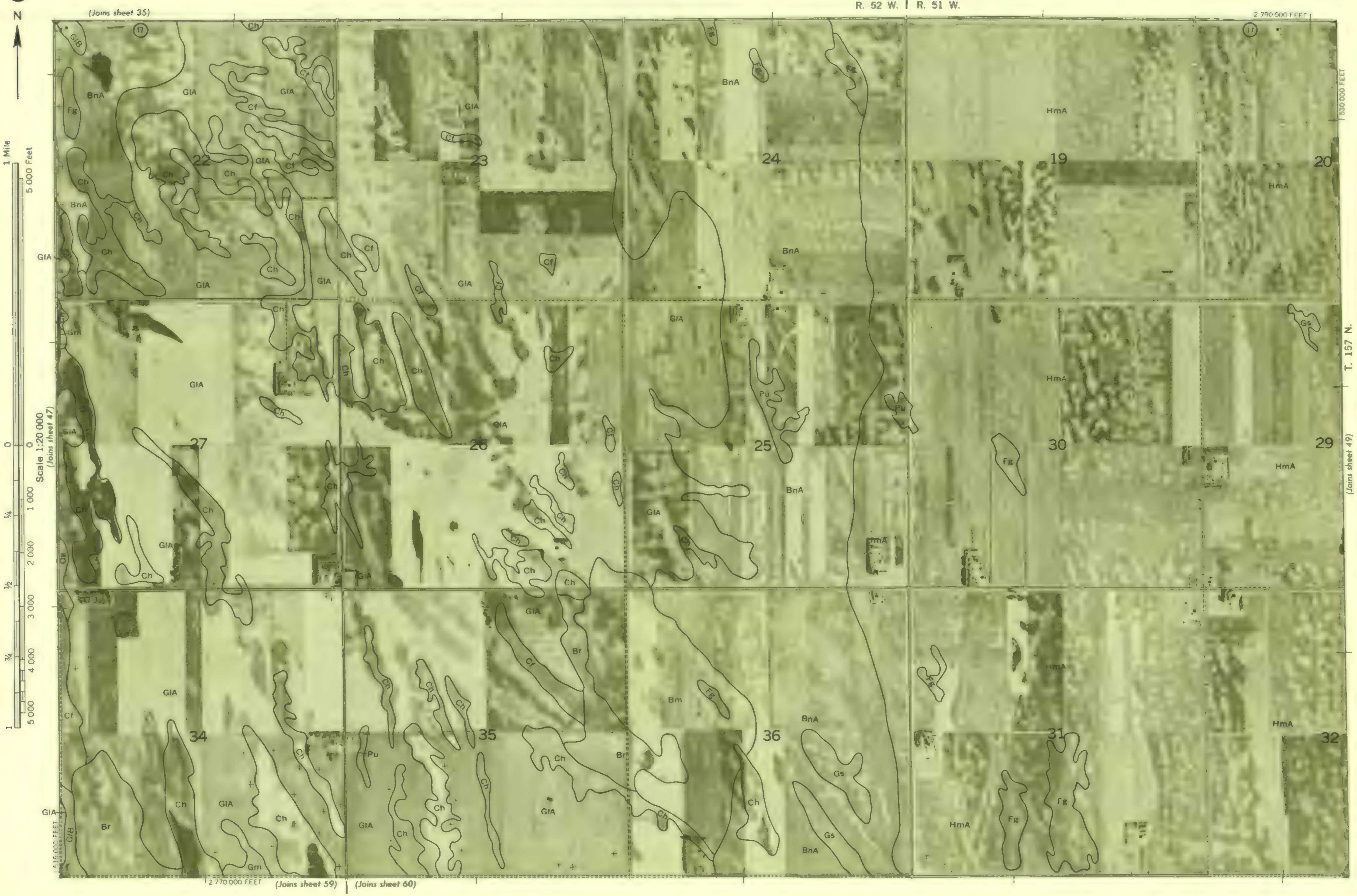
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 47

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 48



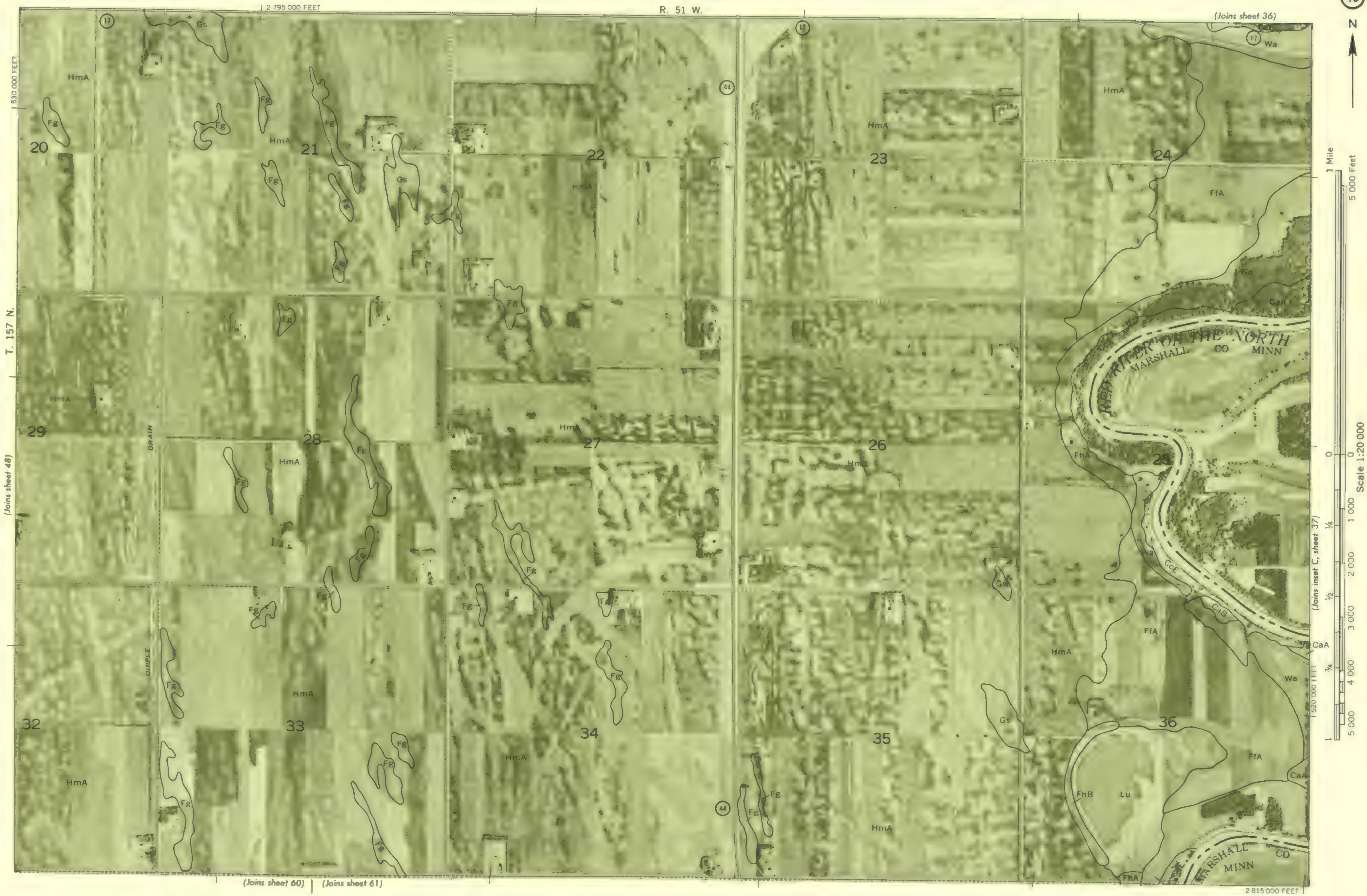
WALSH COUNTY, NORTH DAKOTA NO. 48

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 49



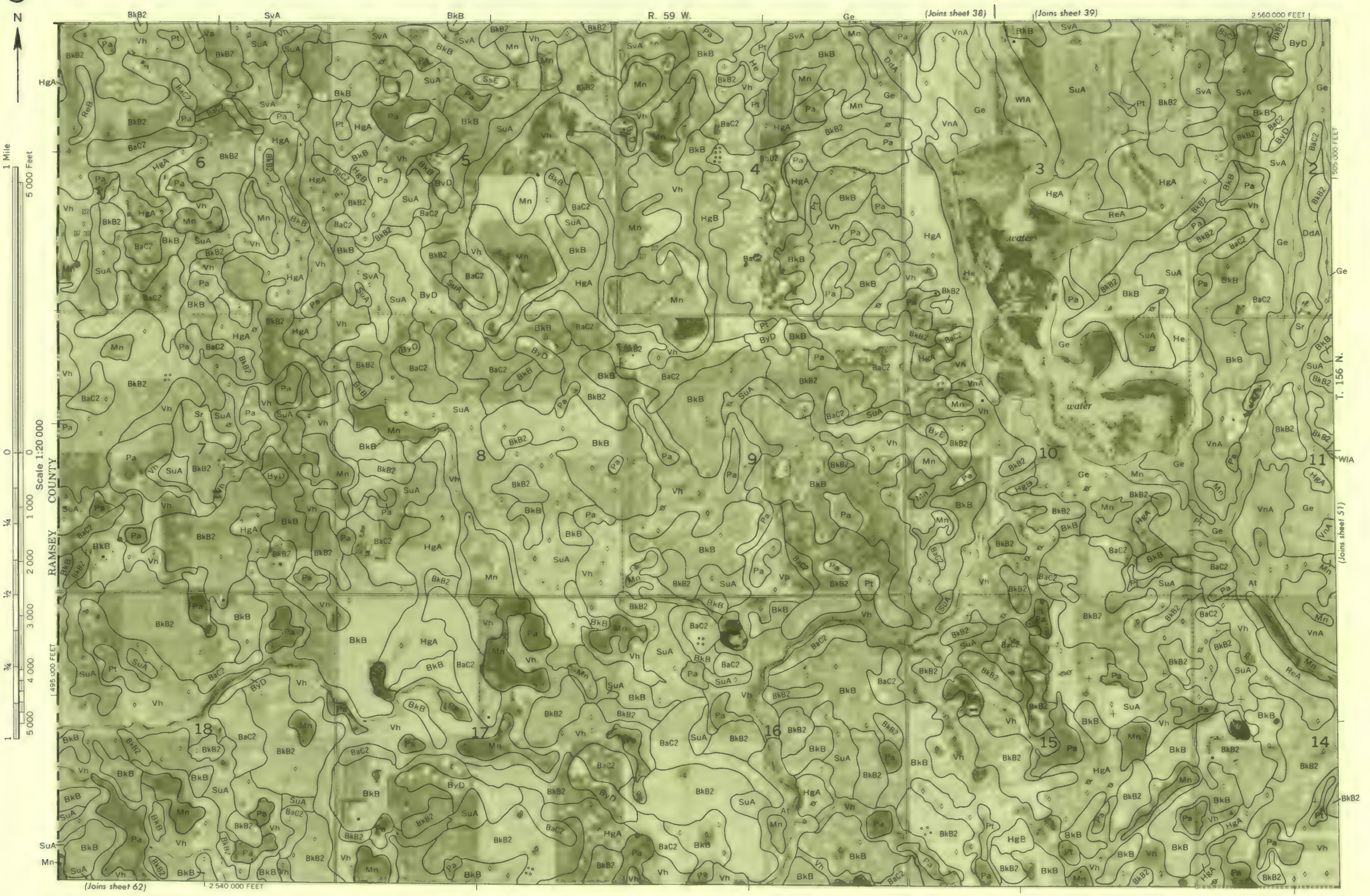
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 49

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 50



WALSH COUNTY, NORTH DAKOTA NO. 50

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 51

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 51

WALSH COUNTY, NORTH DAKOTA NO. 52

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

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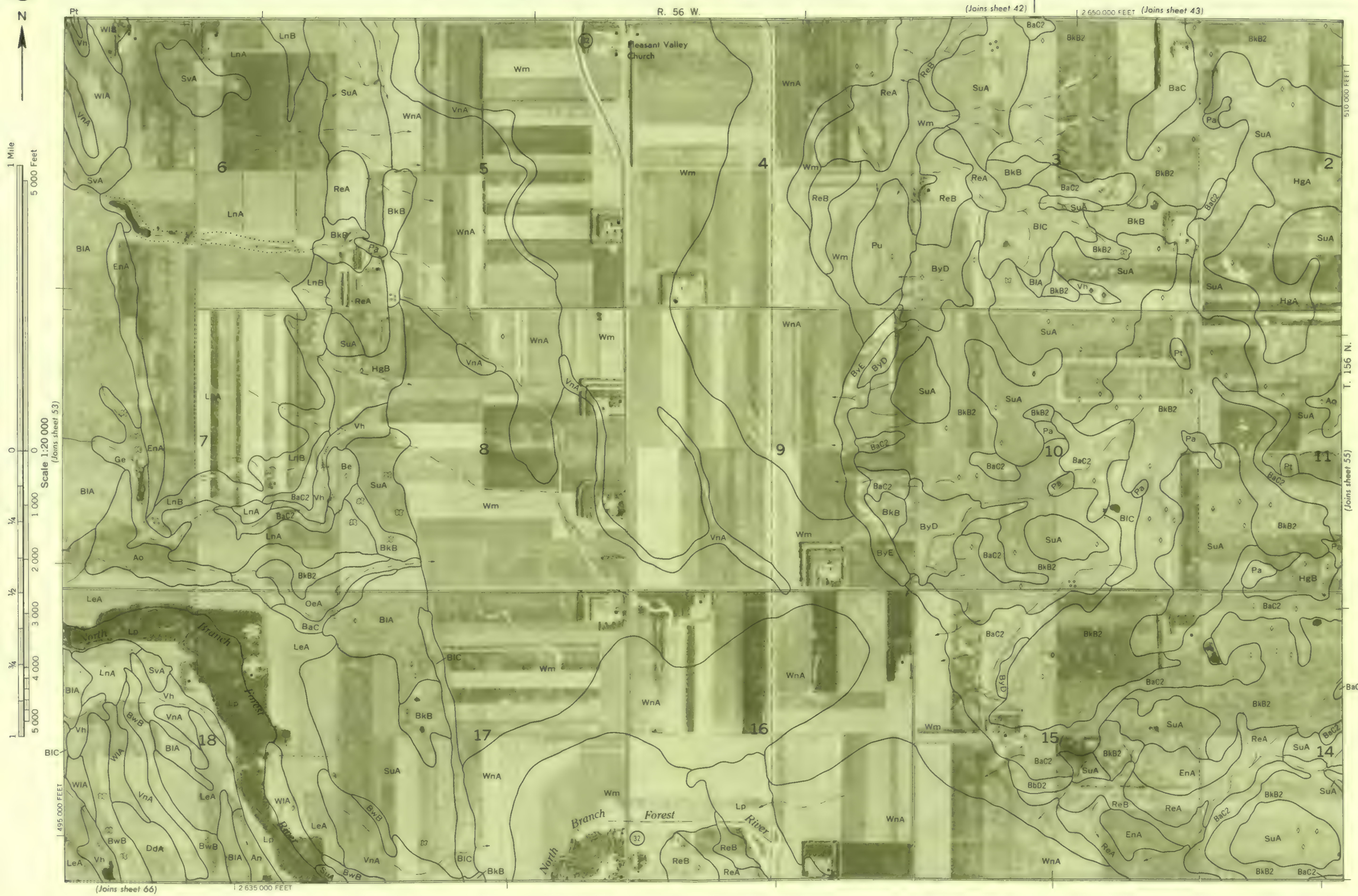
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 53

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 54



WALSH COUNTY, NORTH DAKOTA NO. 54

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

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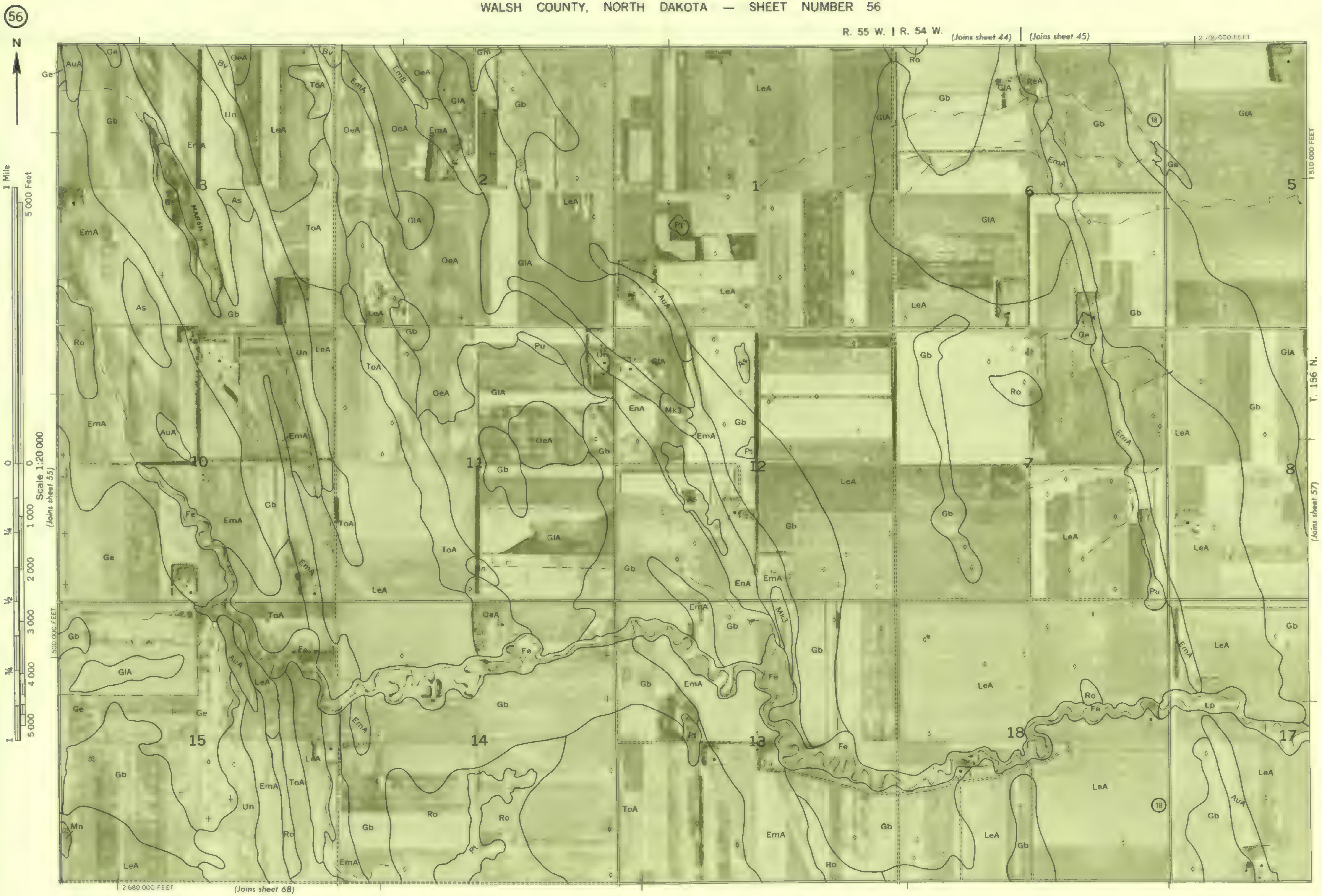
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 55

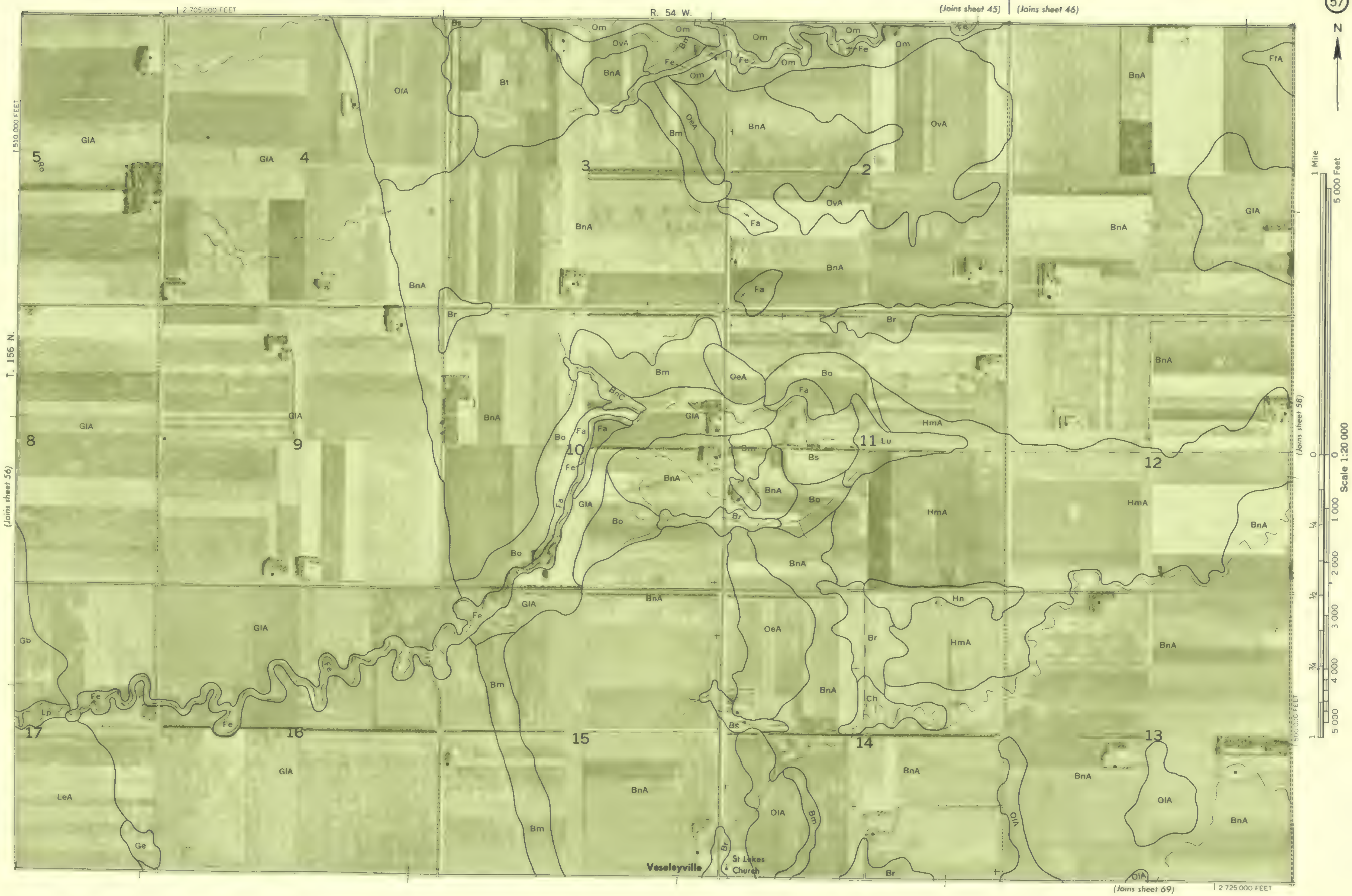


WALSH COUNTY, NORTH DAKOTA NO. 56

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 57



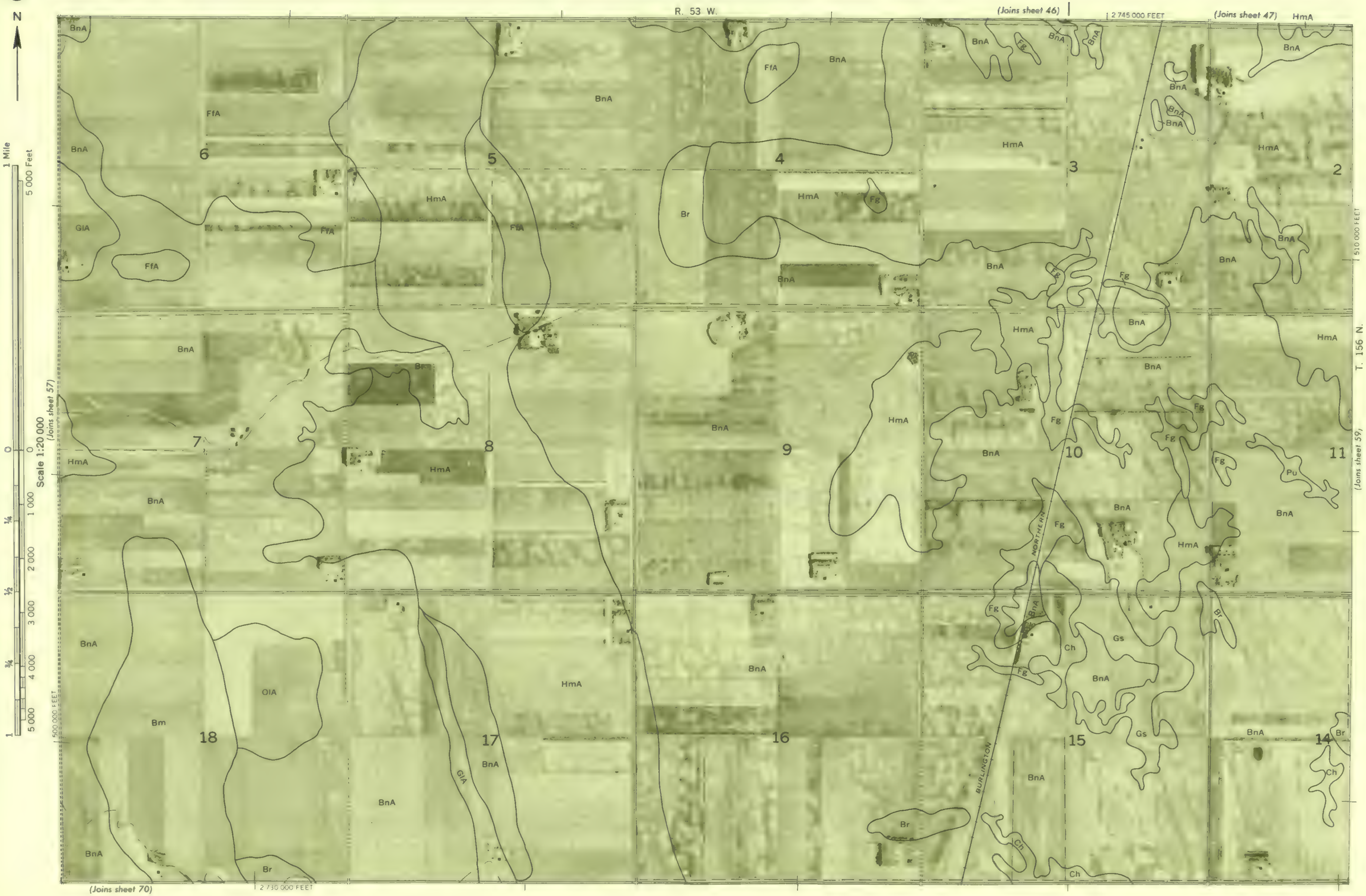
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 57

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 58



WALSH COUNTY, NORTH DAKOTA NO. 58

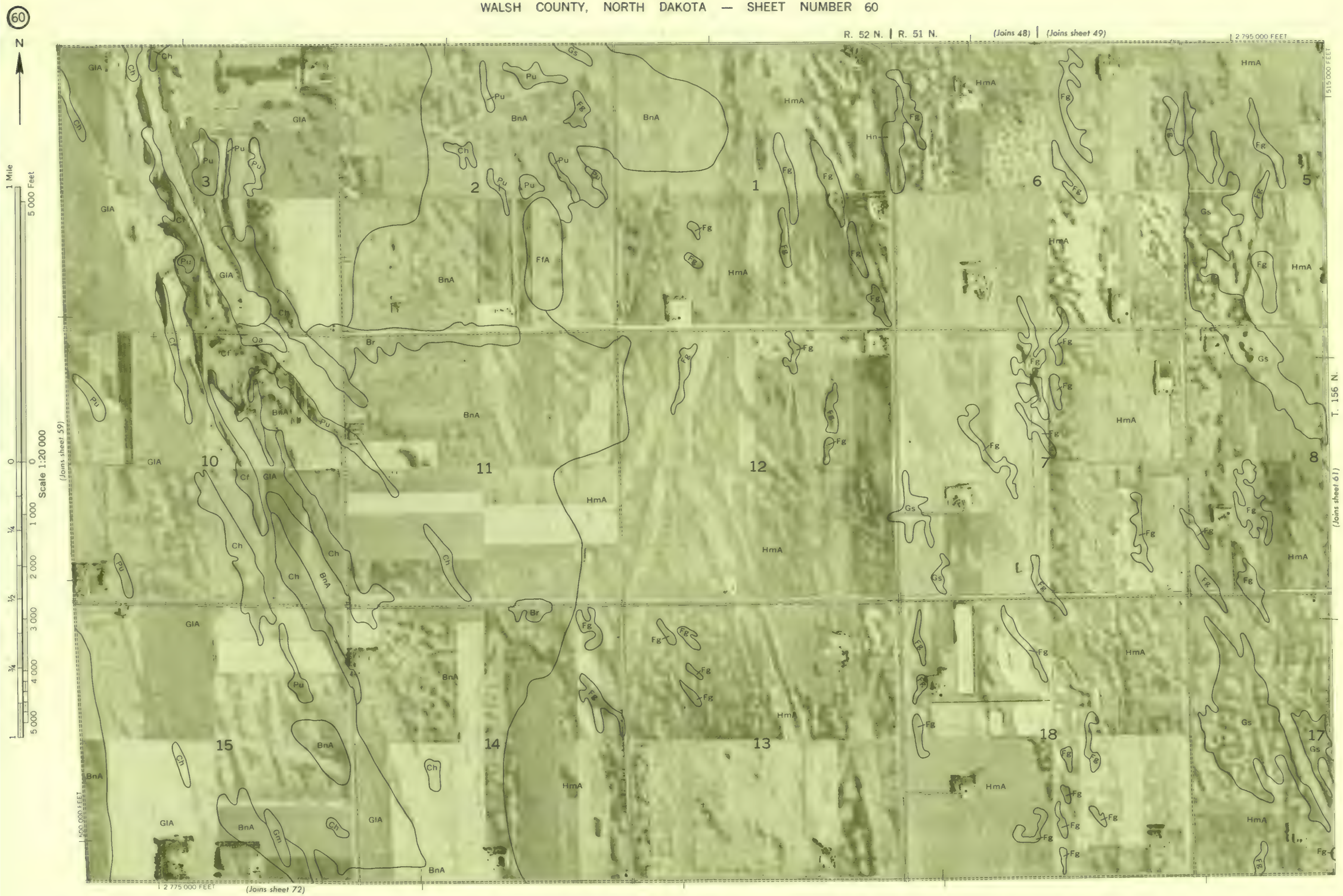
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 59

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 59

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 60



WALSH COUNTY, NORTH DAKOTA NO. 60

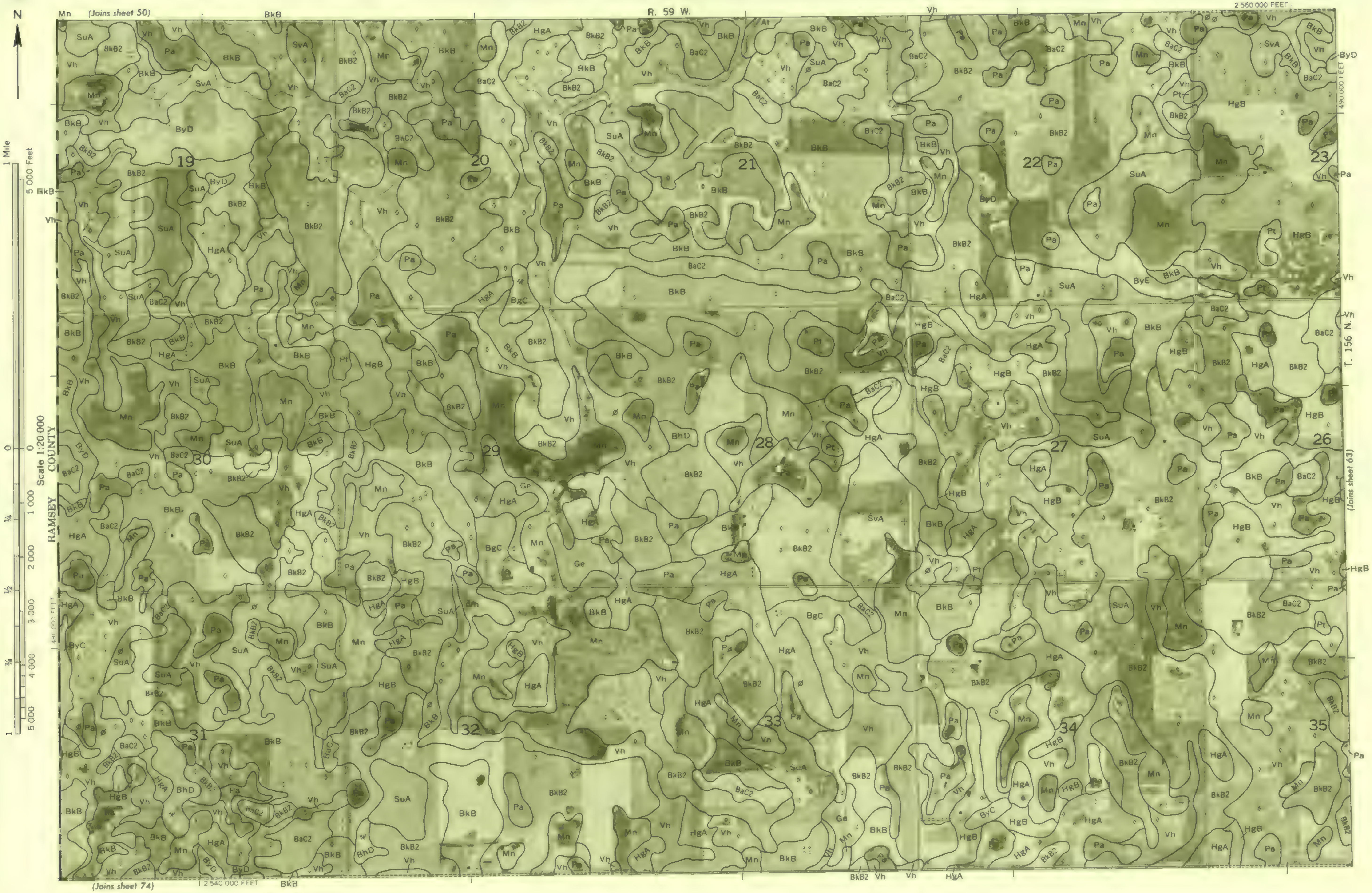
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 62



WALSH COUNTY, NORTH DAKOTA NO. 62

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

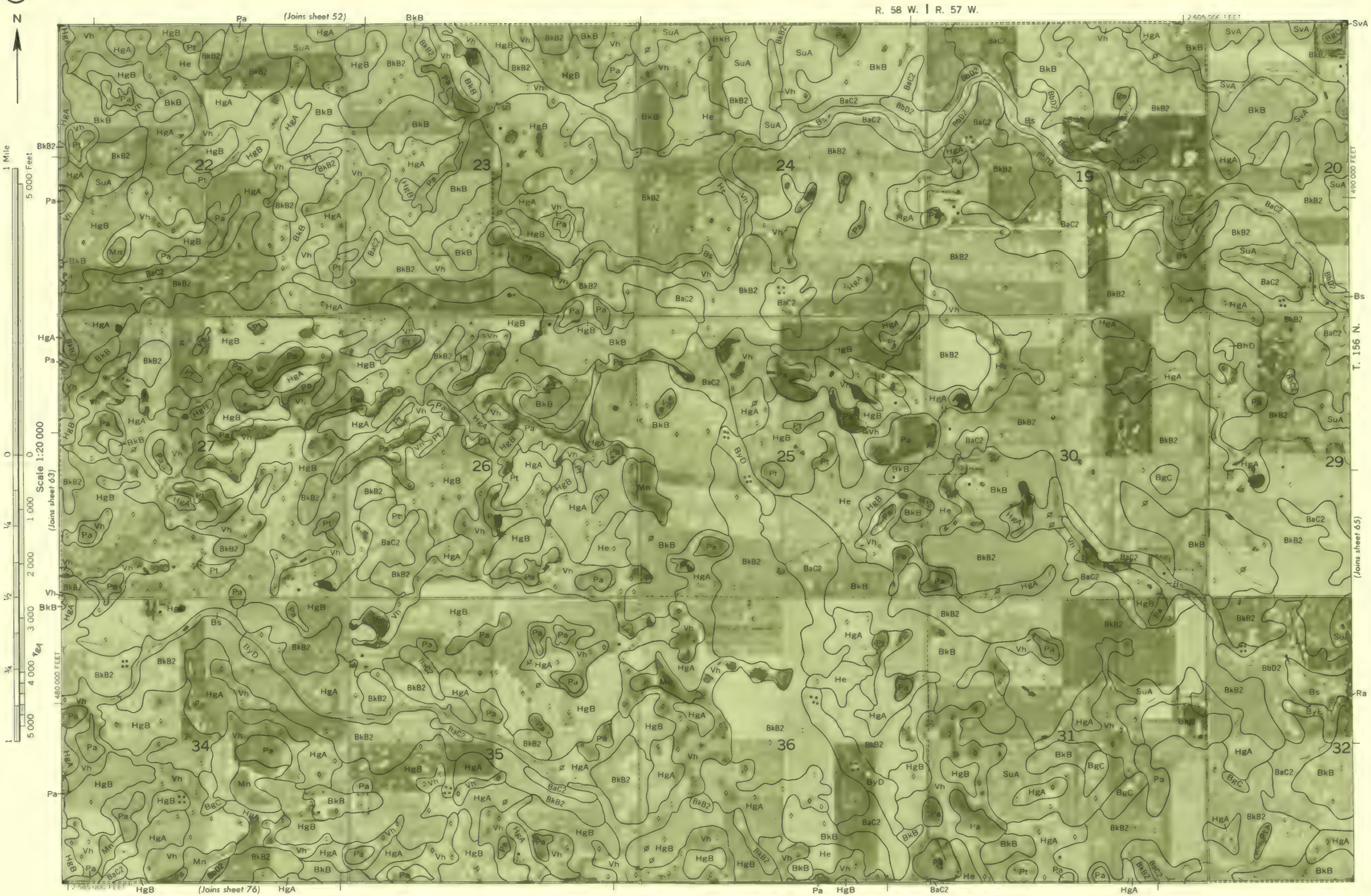
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

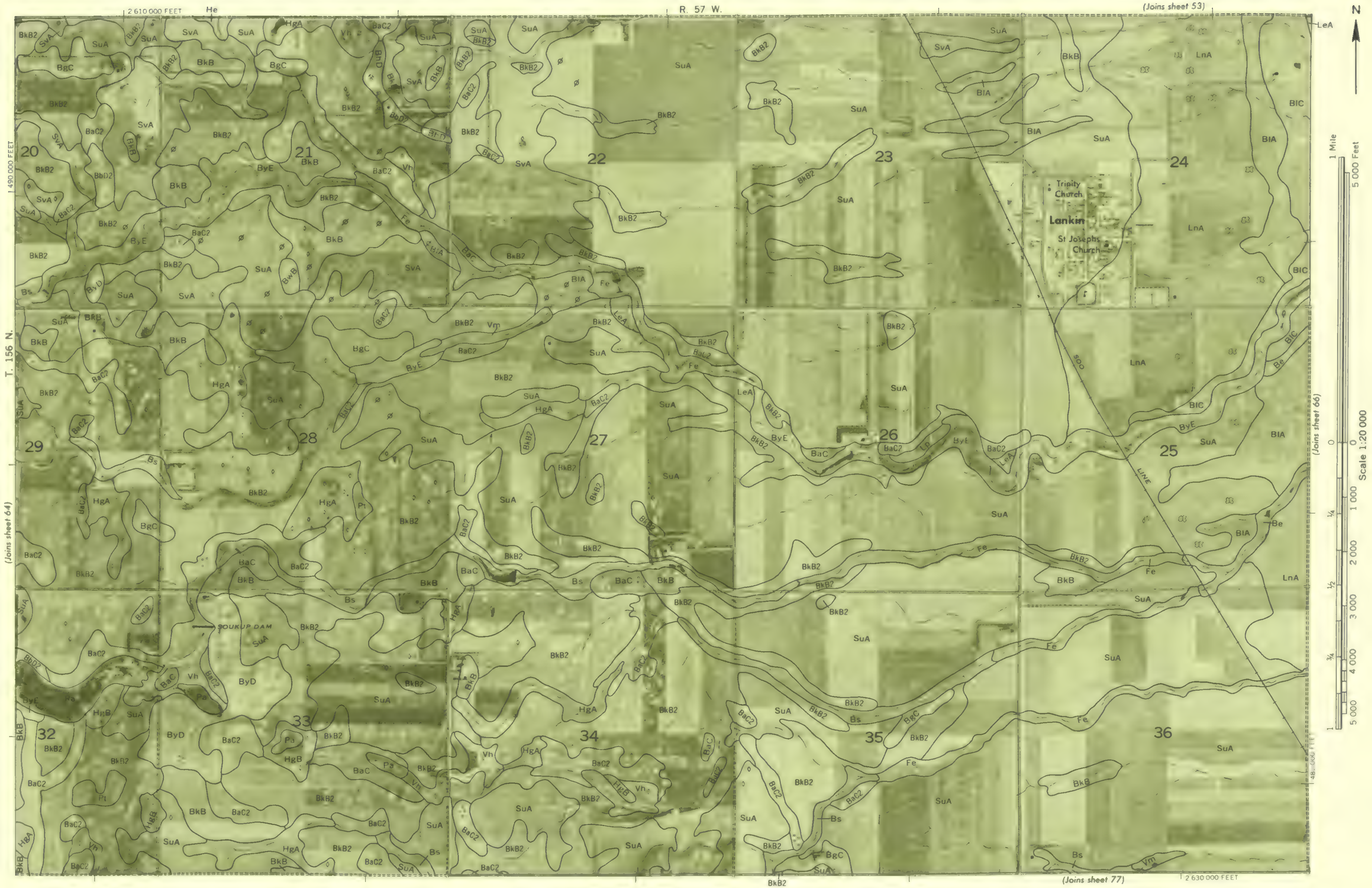
WALSH COUNTY, NORTH DAKOTA NO. 63

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 64



WALSH COUNTY, NORTH DAKOTA NO. 64

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

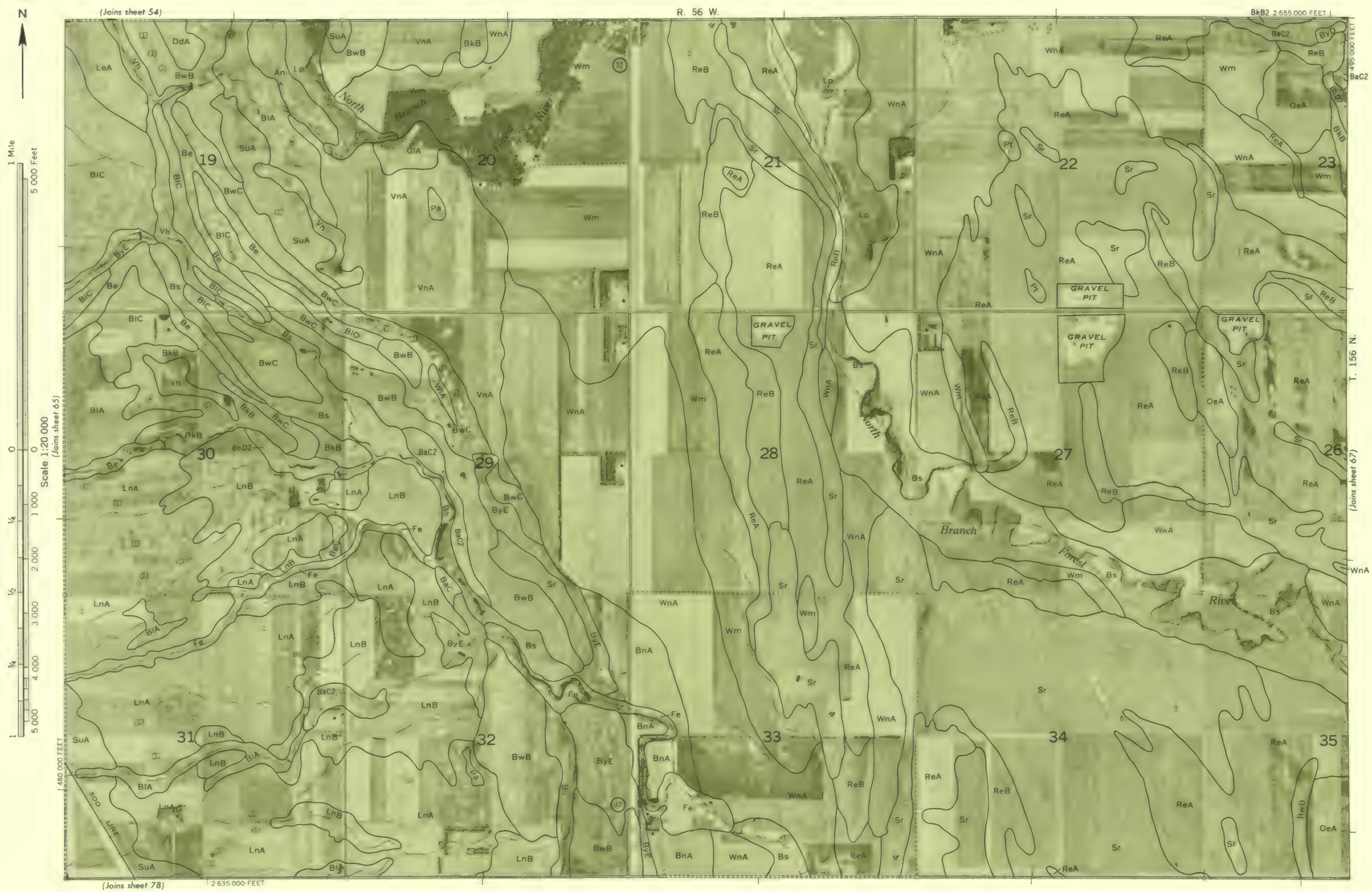


WALSH COUNTY, NORTH DAKOTA NO. 65

Land division corners are approximately positioned on this map.

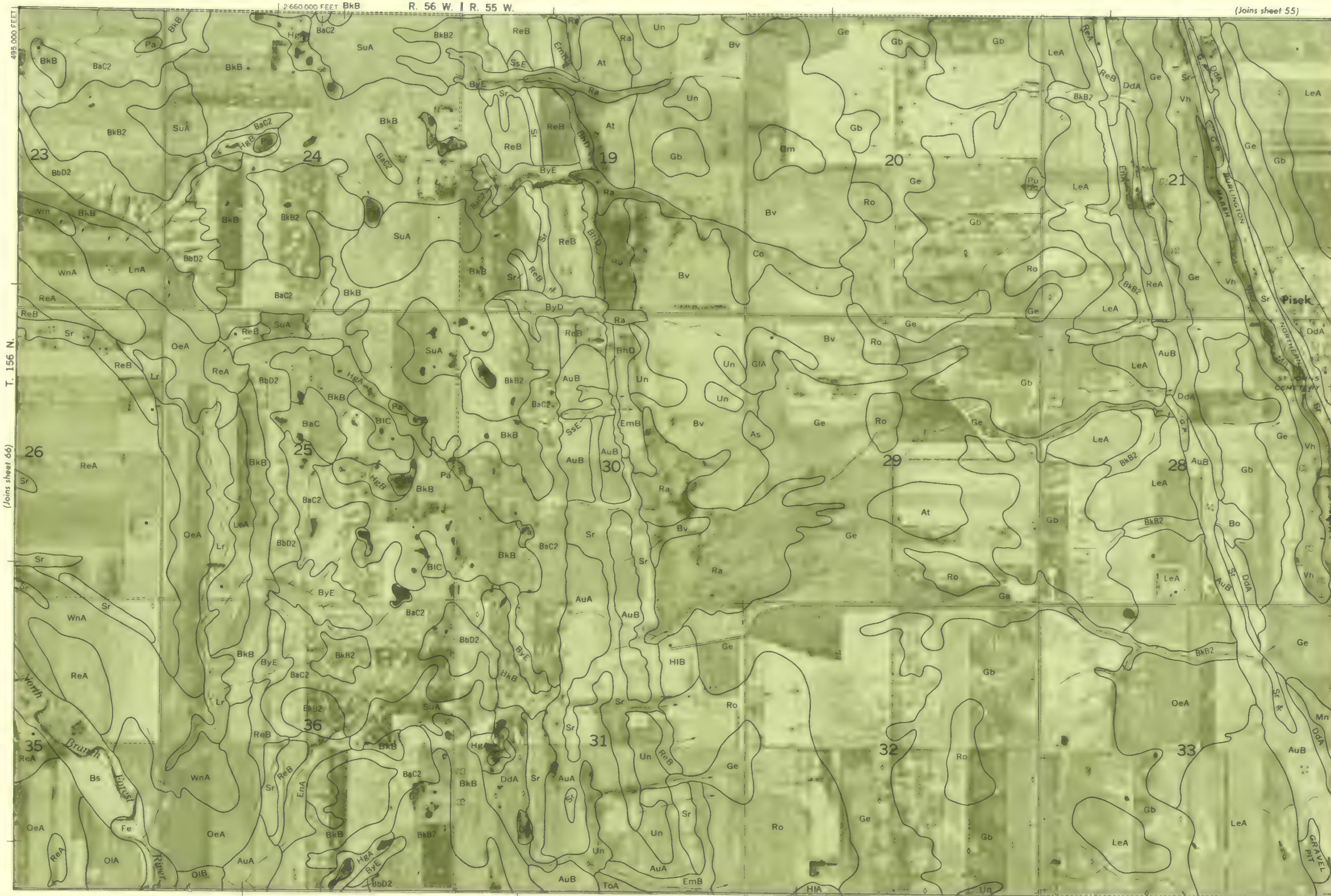
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.



WALSH COUNTY, NORTH DAKOTA NO. 66

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.



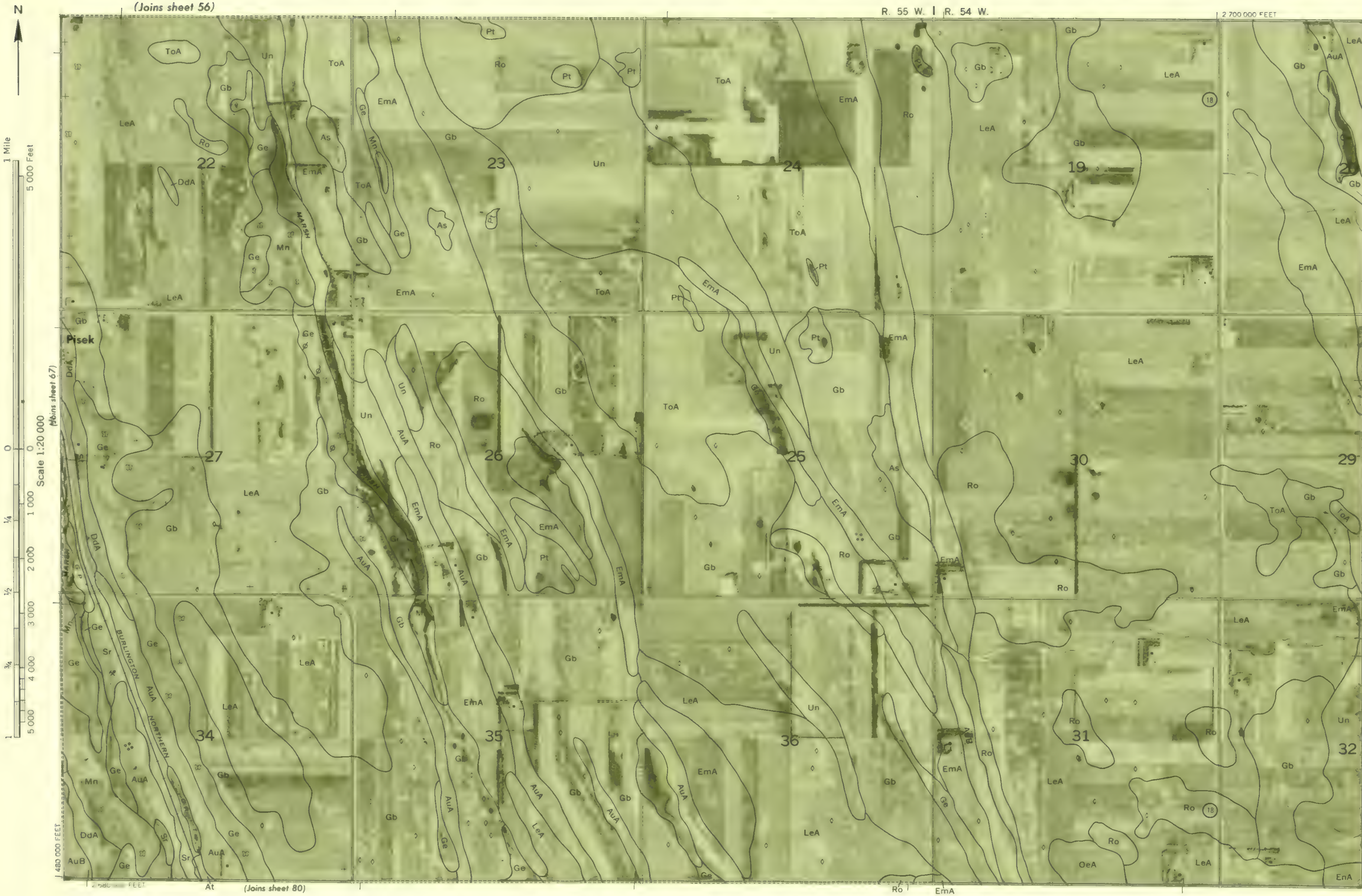
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 67

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 68



WALSH COUNTY, NORTH DAKOTA NO. 68

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 69

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 70

WALSH COUNTY, NORTH DAKOTA NO. 70

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 71

WALSH COUNTY, NORTH DAKOTA NO. 71

Land division corners are approximately positioned on this map.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone 1927 North American datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

72

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 72

N

WALSH COUNTY, NORTH DAKOTA NO. 72

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

73

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 73

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 74

74

WALSH COUNTY, NORTH DAKOTA NO. 74

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station

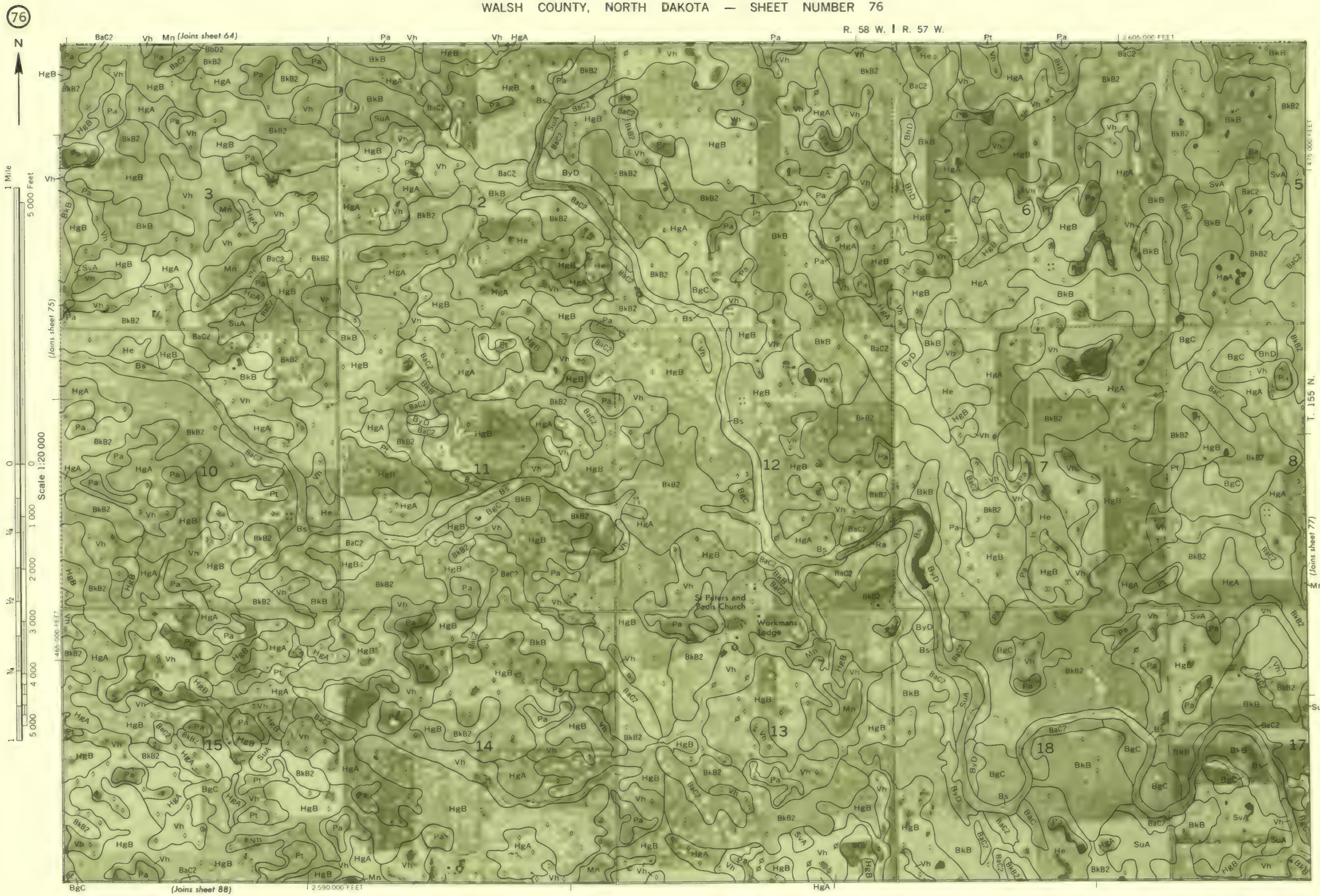
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 75

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 76

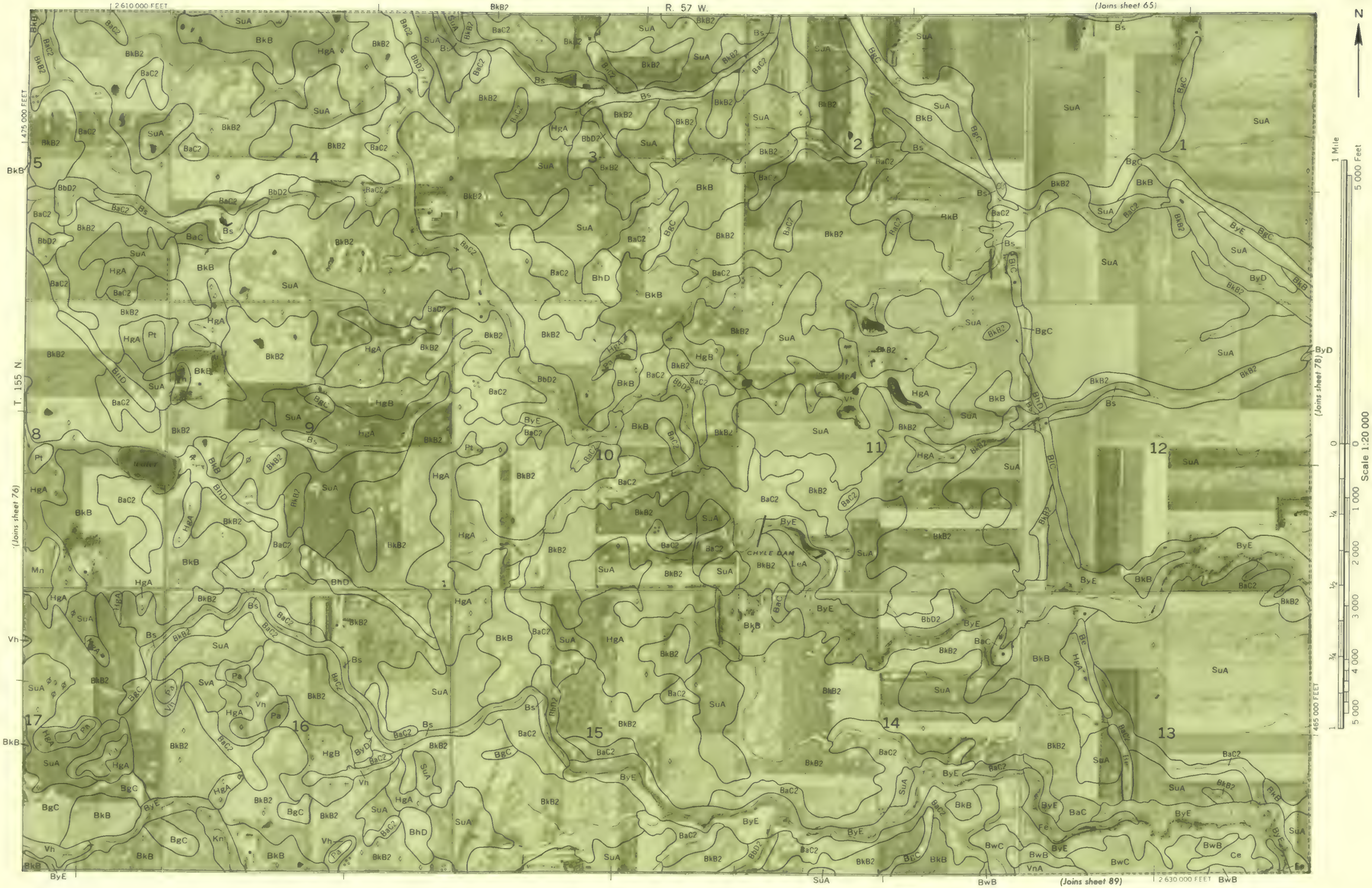


WALSH COUNTY, NORTH DAKOTA NO. 76

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station

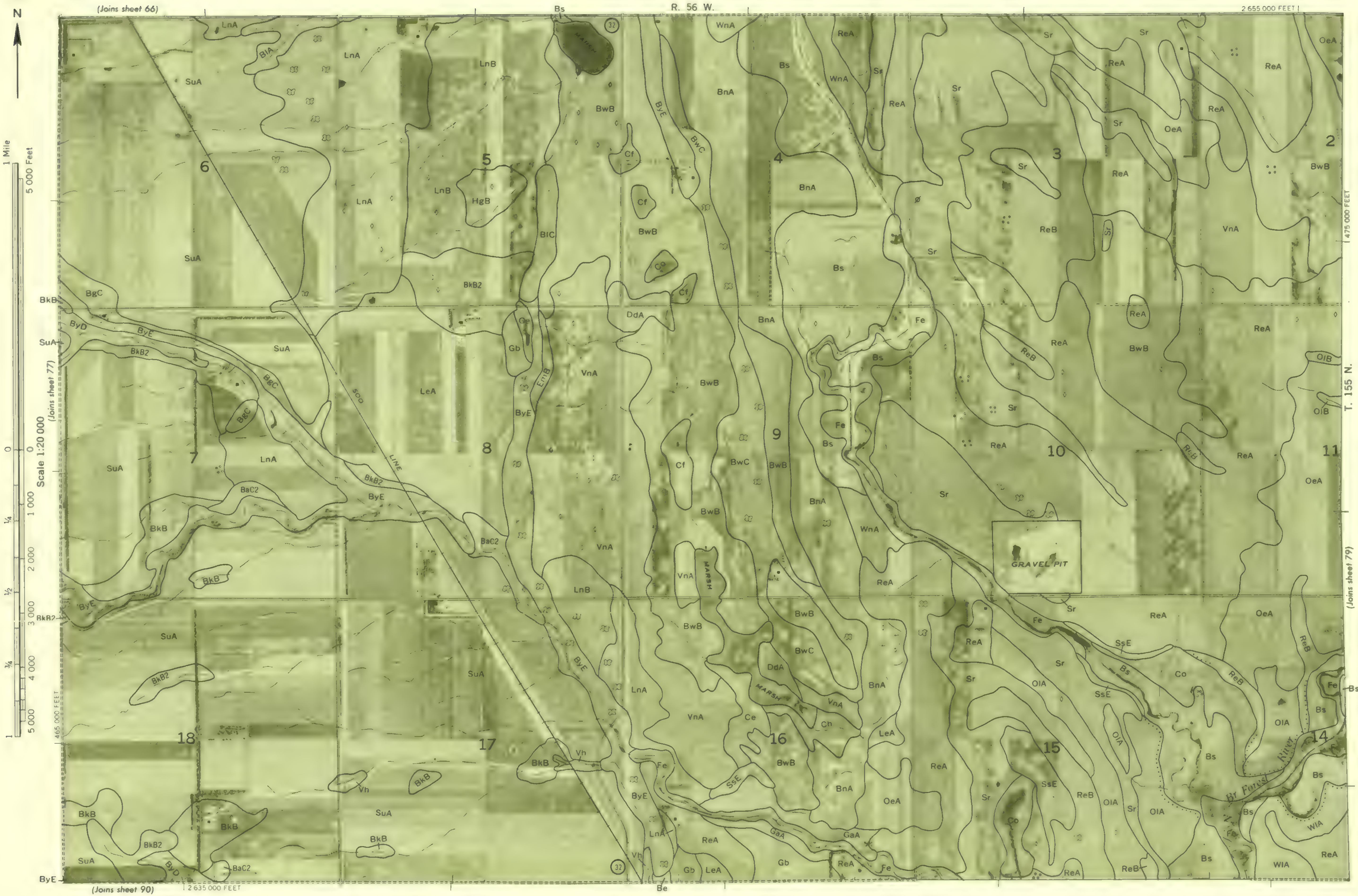
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum
Land division corners are approximately positioned on this map.
WALSH COUNTY, NORTH DAKOTA NO. 77

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 78



WALSH COUNTY, NORTH DAKOTA NO. 78

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone 1927 North American datum

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

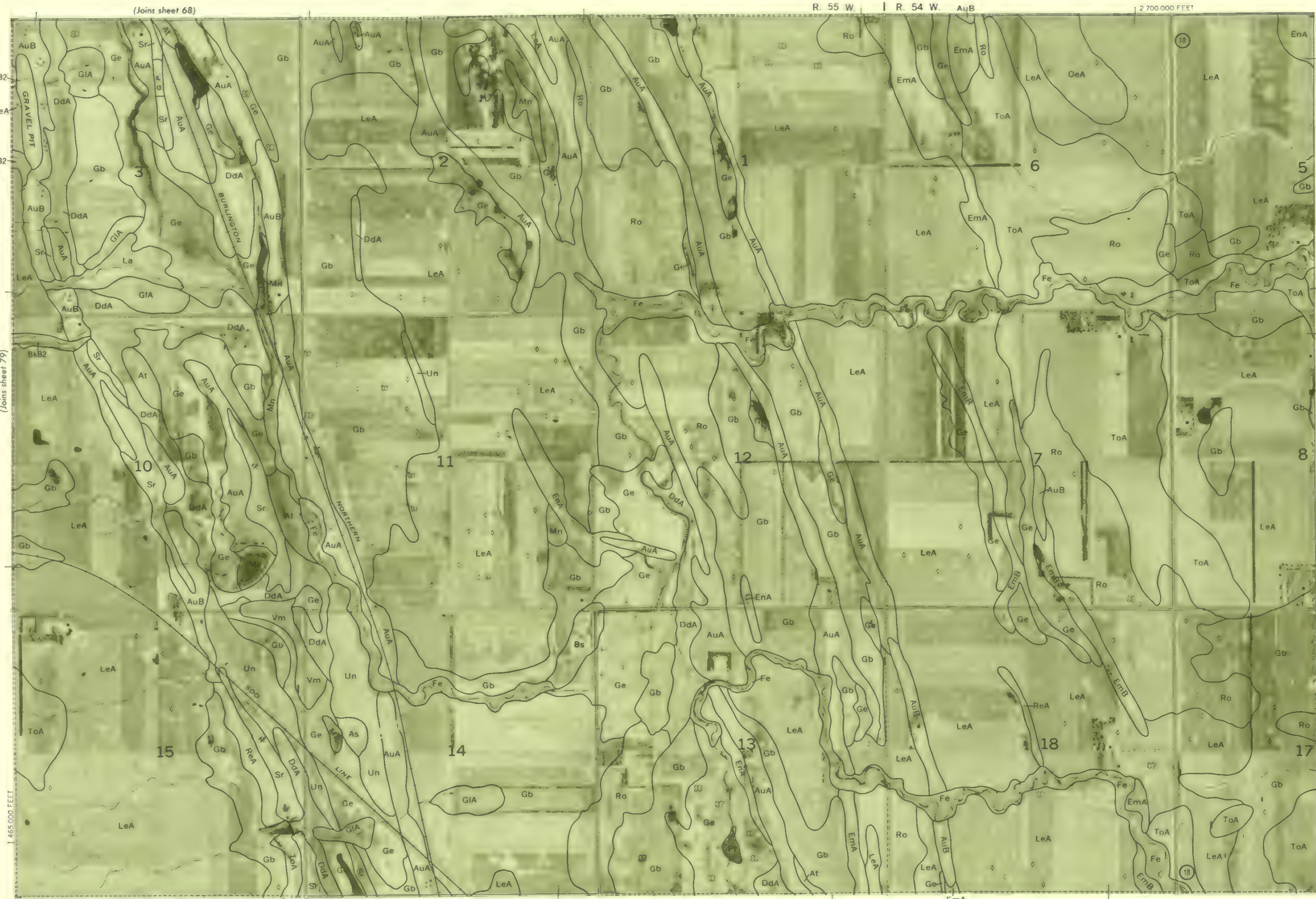
WALSH COUNTY, NORTH DAKOTA NO. 79

N

1 Mile

5 000 Feet

Scale 1:20 000



WALSH COUNTY, NORTH DAKOTA NO. 80

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 81

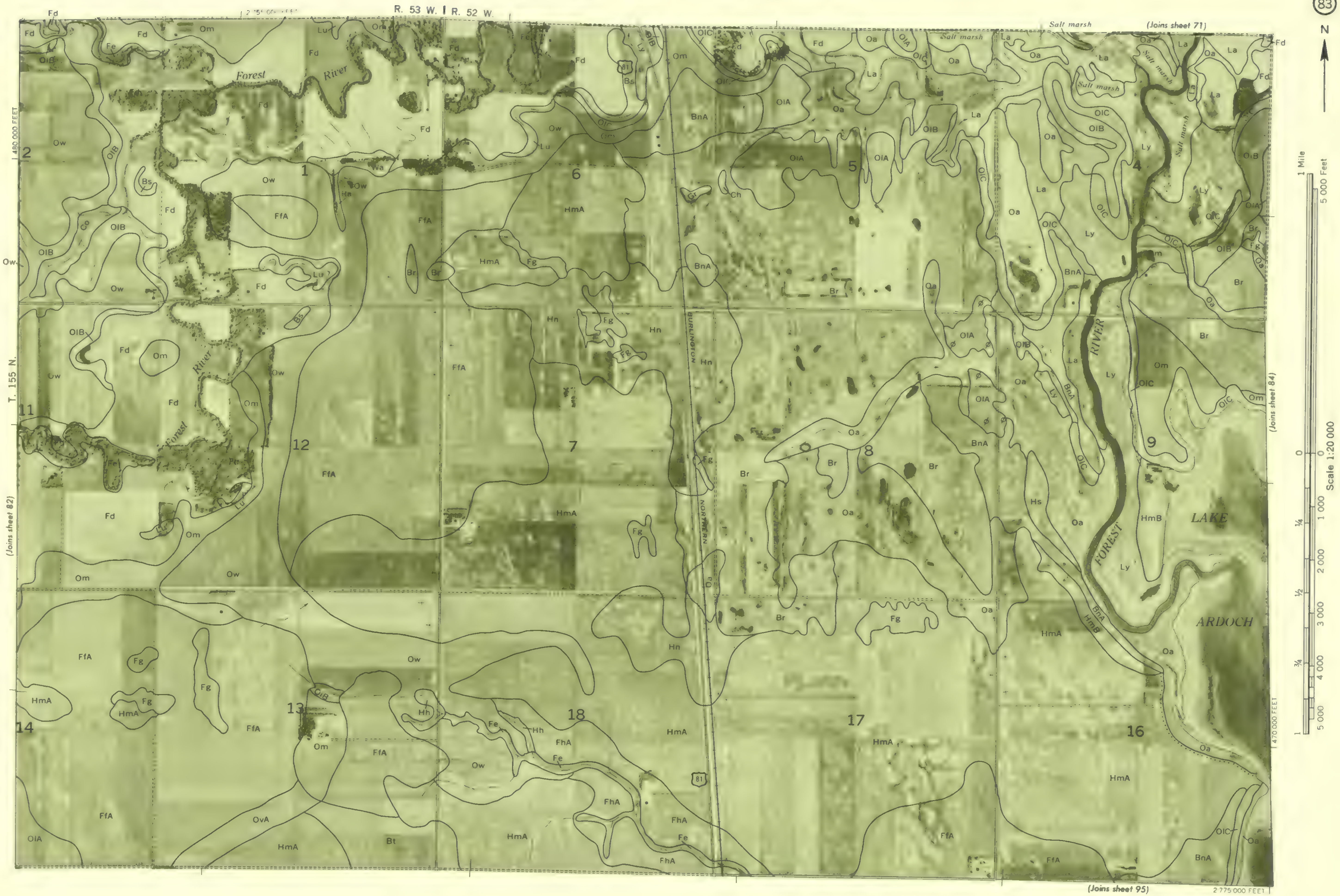
WALSH COUNTY, NORTH DAKOTA NO. 82

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum

Land division corners are approximately positioned on this map

83



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 83

(84)

WALSH COUNTY, NORTH DAKOTA NO. 84

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 85

WALSH COUNTY, NORTH DAKOTA NO. 86

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

87

WALSH COUNTY, NORTH DAKOTA NO. 87

Land division corners are approximately positioned on this map.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 88

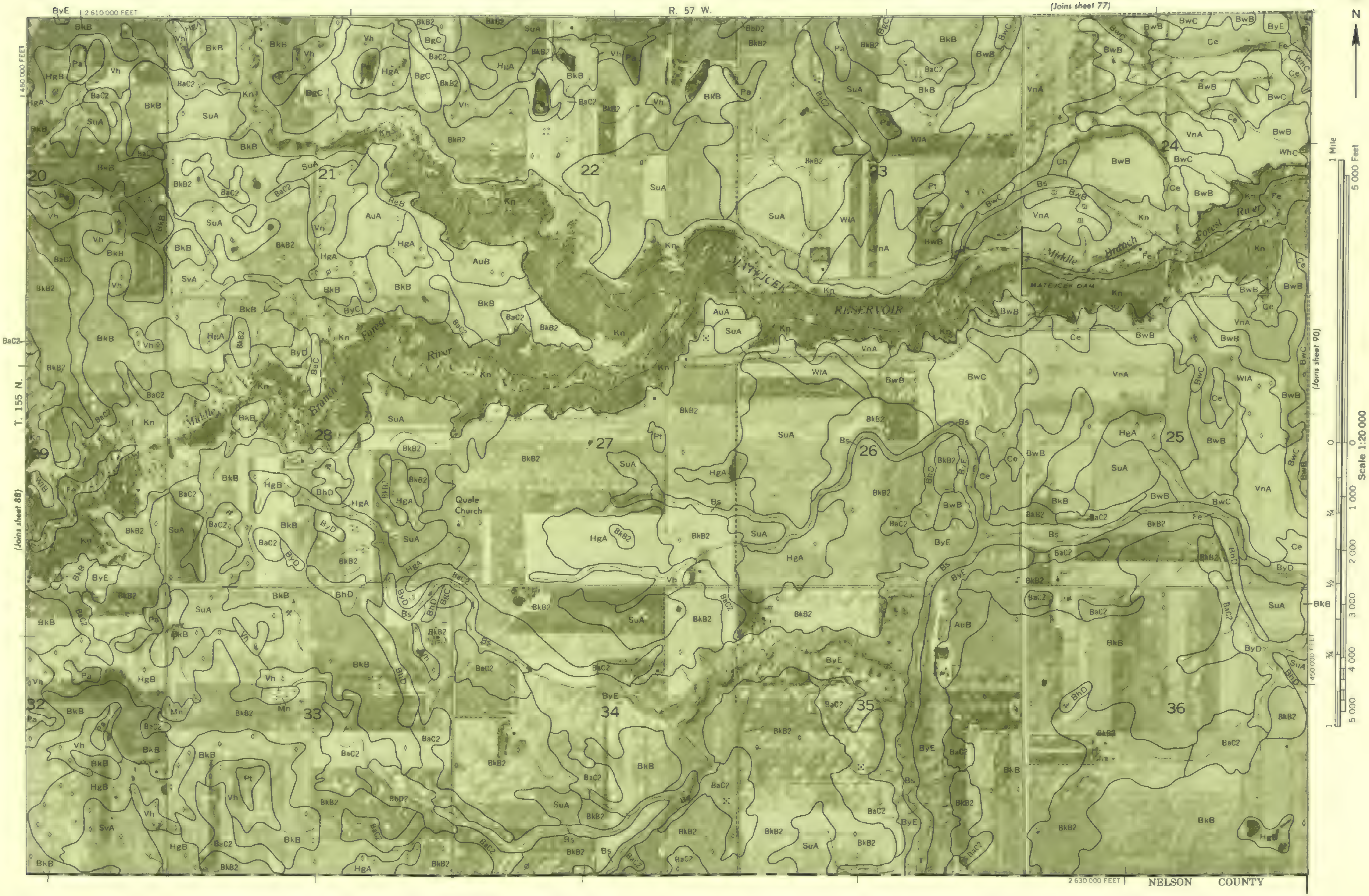
N

1 Mile
5 000 Feet
Scale 1:20 000

WALSH COUNTY, NORTH DAKOTA NO. 88

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

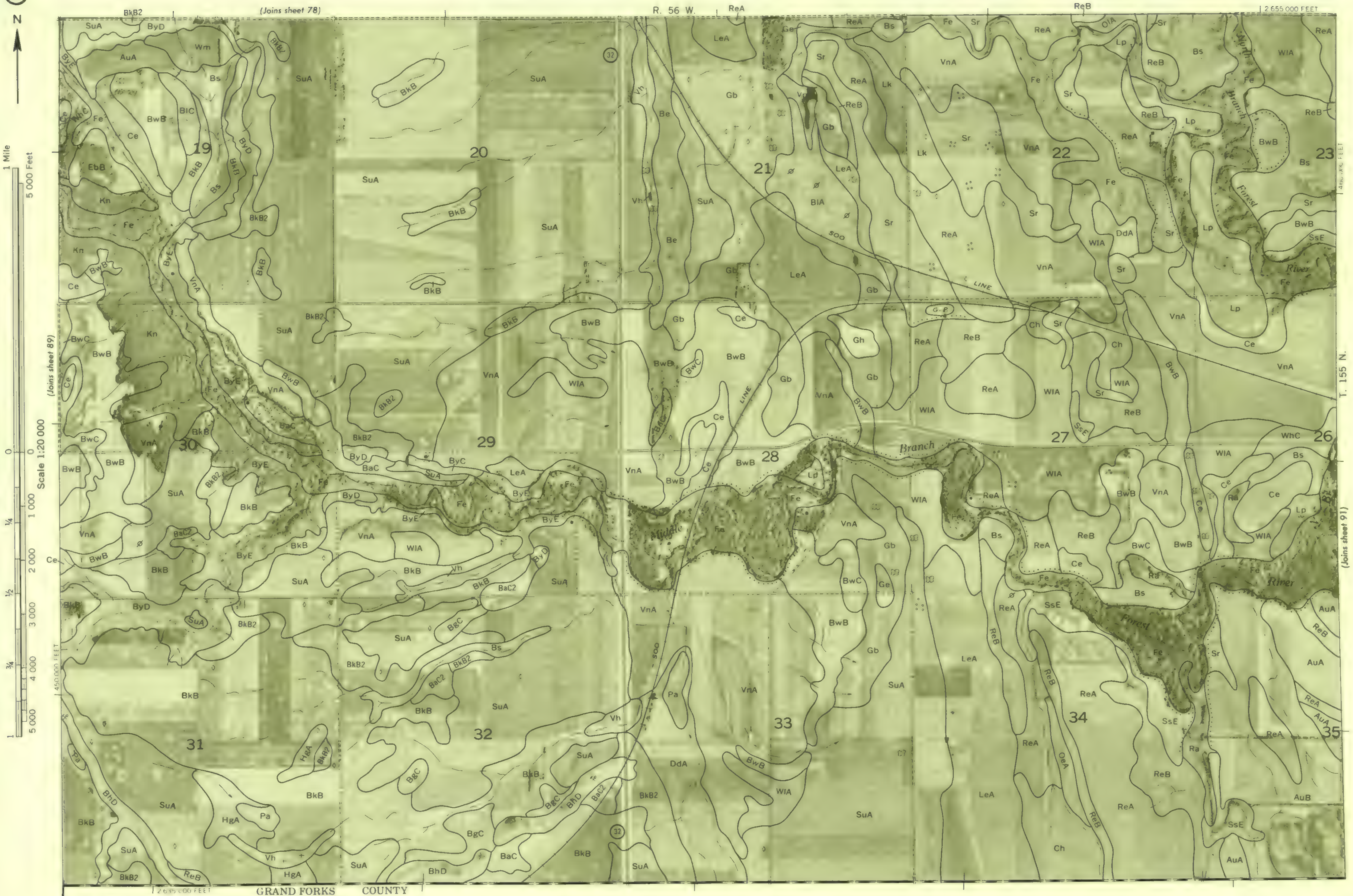
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.
Land division corners are approximately positioned on this map.

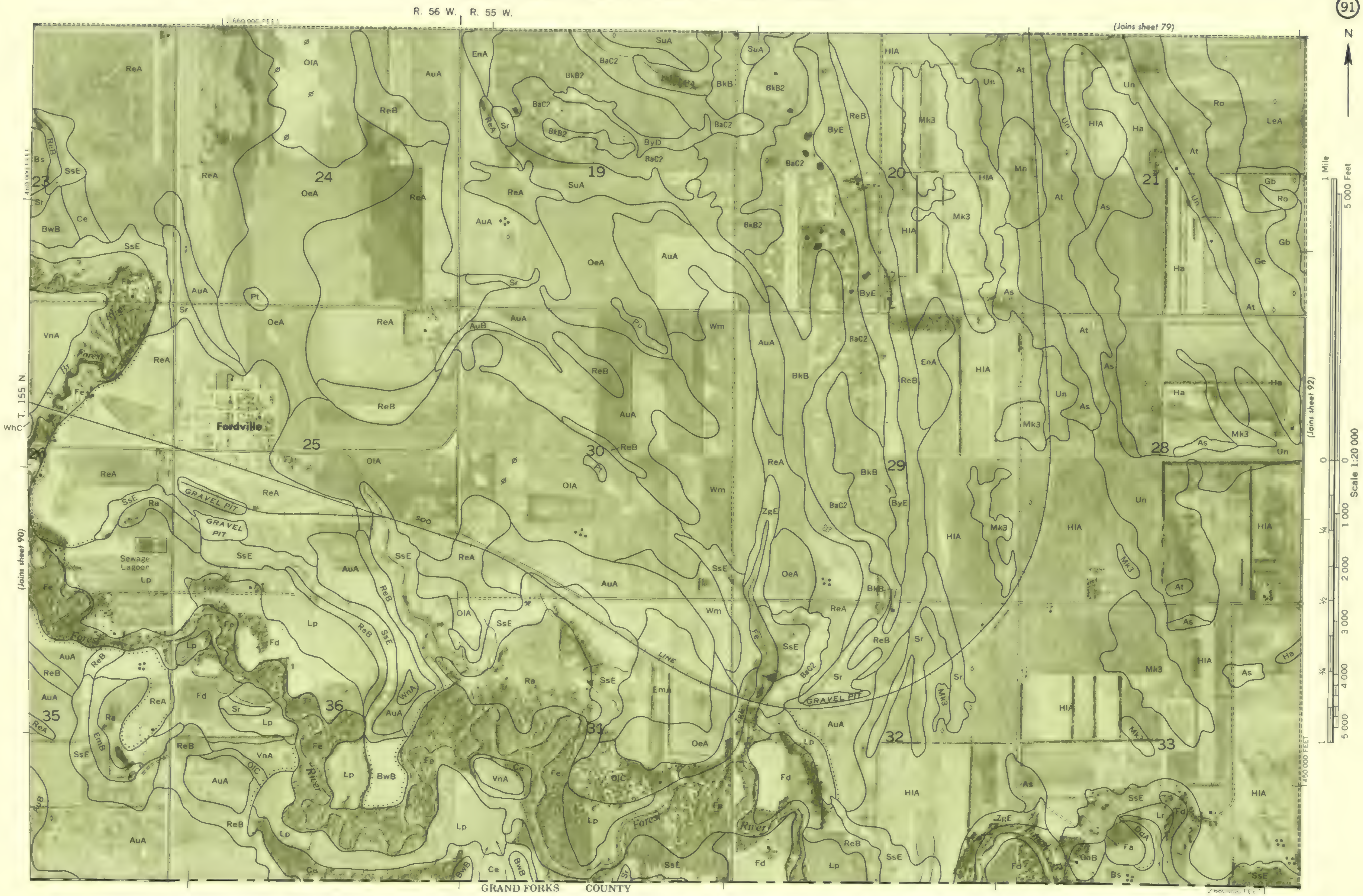
WALSH COUNTY, NORTH DAKOTA NO. 89

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 90



WALSH COUNTY, NORTH DAKOTA NO. 90

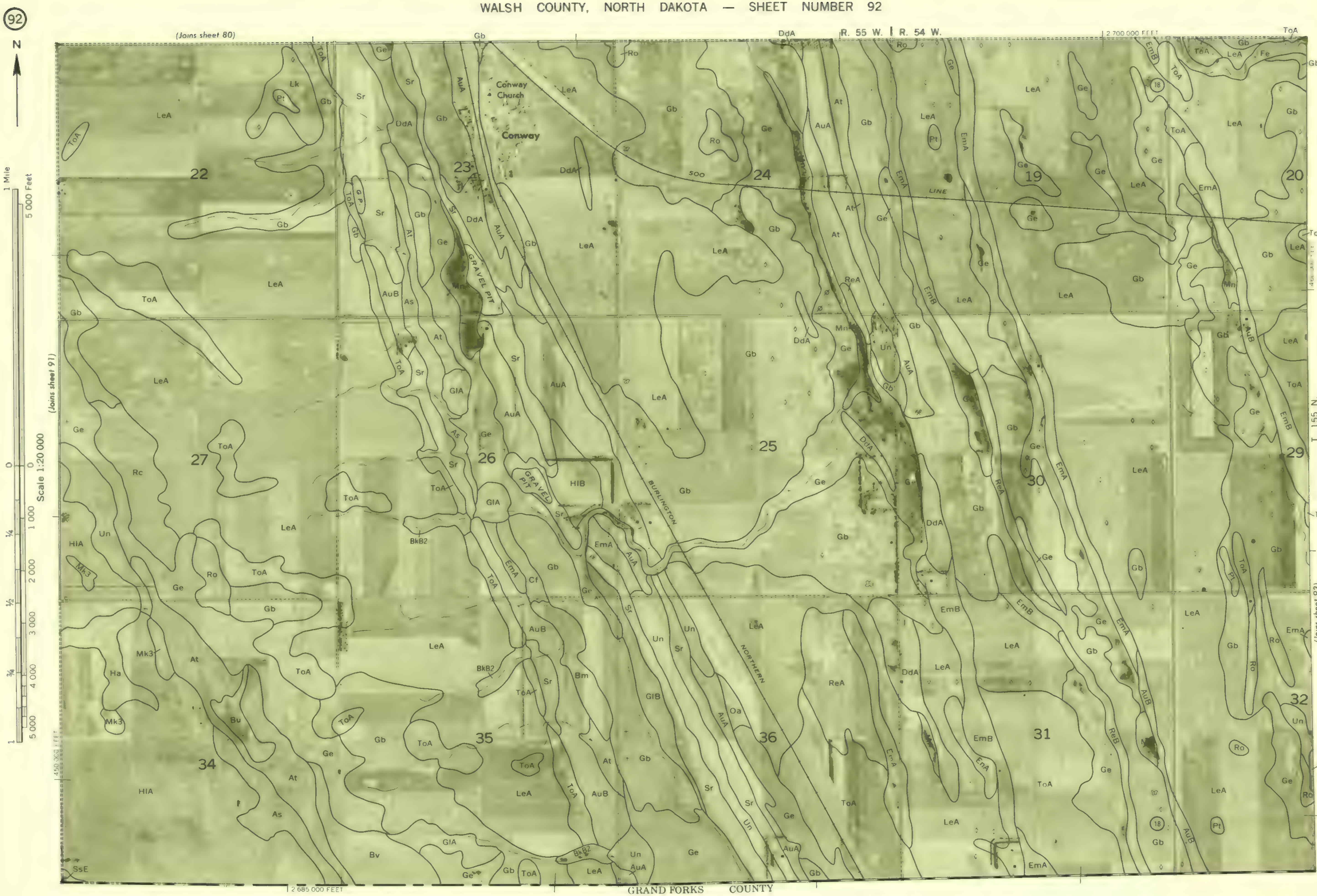
This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 91

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 92



WALSH COUNTY, NORTH DAKOTA NO. 92

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station. Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

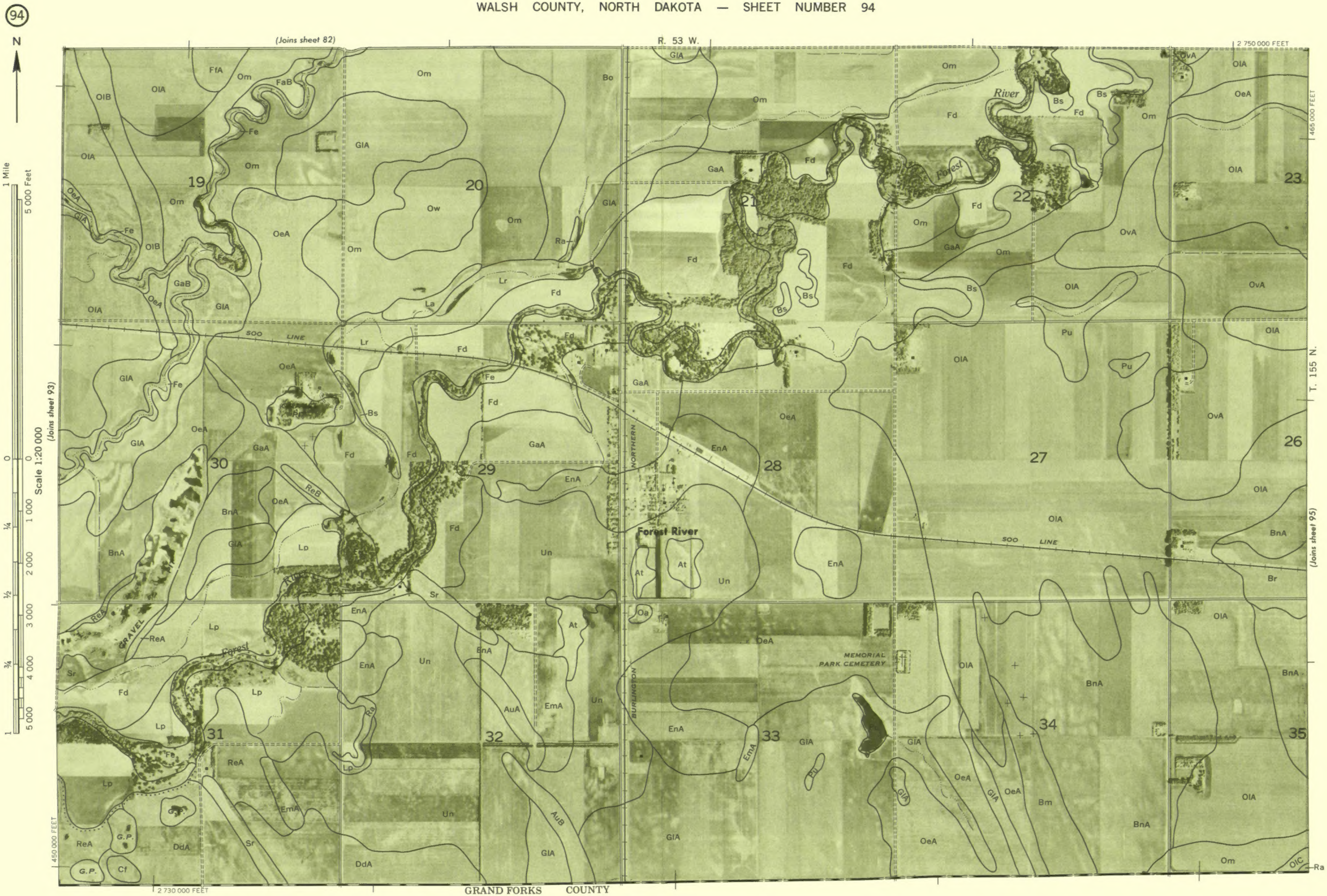
93

WALSH COUNTY, NORTH DAKOTA NO. 93

Land division corners are approximately positioned on this map.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.



WALSH COUNTY, NORTH DAKOTA NO. 94

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.

Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone, 1927 North American datum.

Land division corners are approximately positioned on this map.

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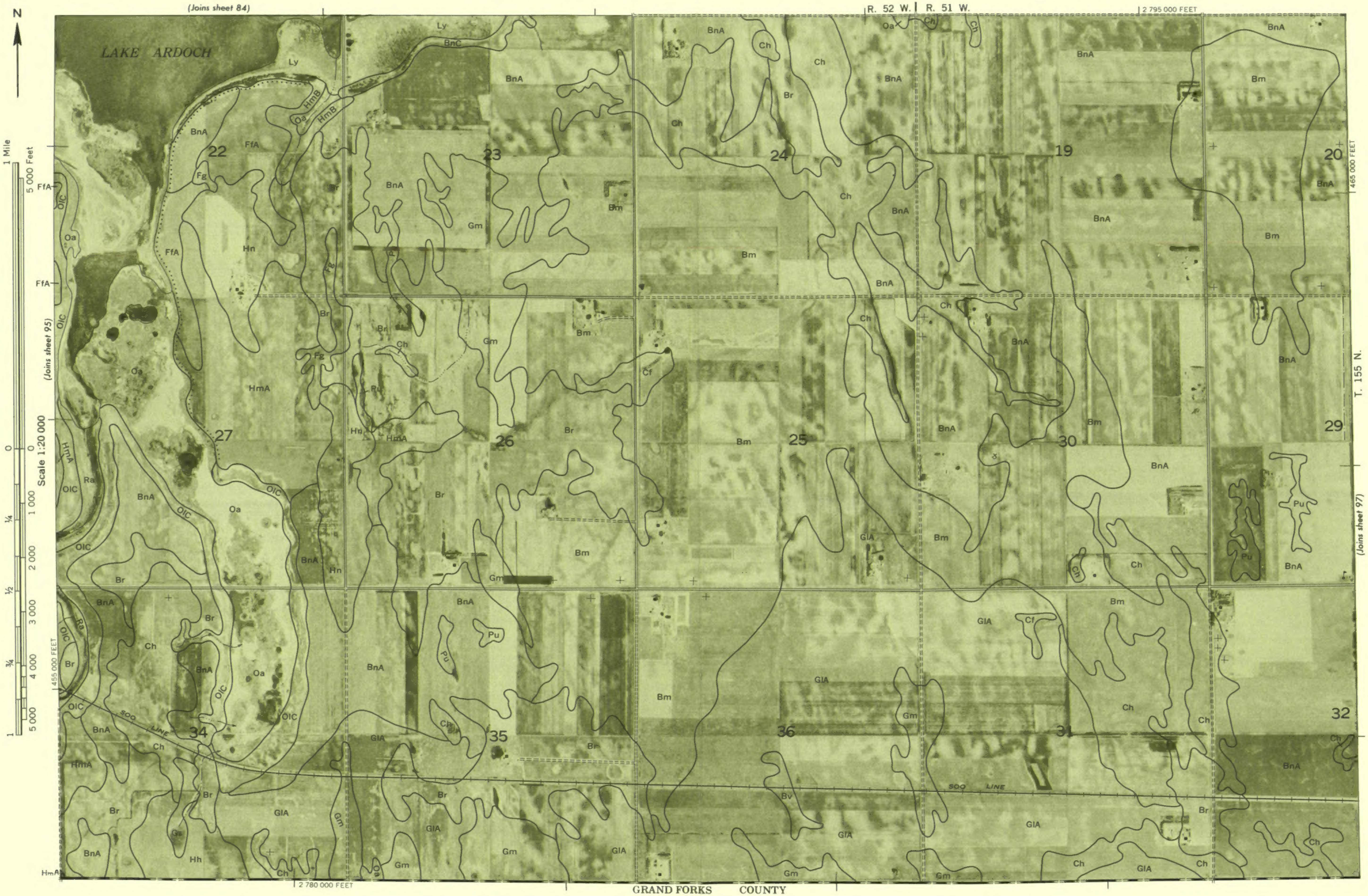
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 95

WALSH COUNTY, NORTH DAKOTA — SHEET NUMBER 96



WALSH COUNTY, NORTH DAKOTA NO. 96

This map is one of a set compiled in 1970 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the North Dakota Agricultural Experiment Station.
Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.
Land division corners are approximately positioned on this map.

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Photobase from 1962 aerial photographs. Grid values based on North Dakota plane coordinate system, north zone. 1927 North American datum.

Land division corners are approximately positioned on this map.

WALSH COUNTY, NORTH DAKOTA NO. 97